Trinity River Winter Flow Project

Final Report
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Trinity River release from Lewiston Dam (photo: TRRP)

Young salmon on the Trinity River (photo: Yurok Fisheries Dept)

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Final Report

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Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

ACRONYMS

Acronym	Definition
°F	degrees Fahrenheit
°C	degrees Celsius
7DADA	seven-day moving average of the daily average
AEAM	Adaptive Environmental Assessment and Management
af	acre-feet
ATU	averaged thermal unit
B120	Bulletin 120
BC	baseline conditions
Basin Plan	Water Quality Control Plan for the North Coast Region
BLM	U.S. Bureau of Land Management
CDFW	California Department of Fish and Wildlife
CEQA	Council on Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
Cmax	maximum potential consumption
CNRFC	California Nevada River Forecast Center
CVP	Central Valley Project
DOI	U.S. Department of the Interior
Draft SIR	Draft Supplementary Information Report
DWR	Department of Water Resources
EA	Environmental Assessment
EIR	Environmental Impact Report
EPA	Environmental Protection Agency
FEIS	Final Environmental Impact Statement
FONSI	Finding of No Significant Impact
Forest Service	U.S. Forest Service
(g)	Daily mass
[g]	grams
HEFS	Hydrologic Ensemble Forecast Service
HVT	Hoopa Valley Tribe
ITAs	Indian Trust Assets
MFF	Maximum Fishery Flow
MWh	megawatt hours
MWMT	Maximum Weekly Maximum Temperature
NEPA	National Environmental Policy Act
NF	North Fork Trinity River
NHPA	National Historic Preservation Act

Acronym	Definition
NOAA	National Oceanic and Atmospheric Administration
North Fork	North Fork Trinity River
OCAP	Operations Criteria and Plan
pCmax	proportion of Cmax
Program	Trinity River Restoration Program
Reclamation	U.S. Bureau of Reclamation
RBM10	River Basin Model-10
Regional Water Board	North Coast Regional Water Quality Control Board
ROD	Record of Decision
SAB	Science Advisory Board
SIR	Supplementary Information Report
S3	Stream Salmon Simulator
TAF	Thousand Acre-Feet
TARGETS	Target Species
TMC	Trinity Management Council
TRD	Trinity River Division
TRFES	Trinity River Flow Evaluation Study
Trinity Gen	Trinity Power Generation
Trinity River FEIS	Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement
TRRP or Program	Trinity River Restoration Program
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WY	Water year

1. History of the Winter Flow Project

1.1 Introduction

This report has been prepared to summarize and provide the history, scientific rationale, and anticipated outcomes of the Winter Flow Project (Winter Flow Project or Project) proposed by the Trinity River Restoration Program (TRRP or Program). The Winter Flow Project activities described in this report are designed to support the TRRP's goal of restoring fish populations to pre-dam levels and restoring dependent fisheries, including those held in trust by the federal government for the Hoopa Valley and the Yurok Tribes, as mandated by Congress and outlined in the 2000 Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement (Trinity River FEIS; USFWS et al. 2000b), and the Record of Decision (USFWS et al. 2000a; Gaeuman and Stewart 2017).

The Winter Flow Project, described in detail in Section 2, proposes to shift a portion of the ROD water volume used for restoration releases in the spring to the winter period to improve anadromous fish habitat conditions along the TRRP's restoration reach, which is the approximately 40-mile length of the Trinity River downstream of Lewiston Dam to the confluence of the North Fork Trinity River (also referred to as the "North Fork") in Trinity County, California (Figure 1-1).

As stated in the Trinity River Flow Evaluation Study (TRFES; USFWS and HVT 1999), "No high-flow release(s) are planned, but synchronization of peak releases with stormflows should be evaluated through the adaptive management program to assess opportunities to maximize benefits of high-flow releases while conserving water." The Trinity River FEIS and the ROD, however, do not provide a logistical framework necessary to implement changes to the ROD flow regime. This lack of guidance and perceived lack of environmental permitting compliance under the current FEIS has stifled previous efforts to shift flow from the spring period to the winter months. The Winter Flow Project presented in this report provides an operational framework for implementing a winter flow synchronization regime.

1.1.1 Purpose of the Winter Flow Project

The purpose of the Winter Flow Project is to refine the timing of restoration flows using the principle of adaptive management to better meet geomorphic, fish habitat, and temperature objectives of the ROD. Moving a portion of the ROD volume released from Lewiston Dam to the winter period as an initial flow management action would benefit the Trinity River ecological processes and Trinity Reservoir management in these ways:

- Adjust the timing of restoration releases from Lewiston Dam to better match natural flow variability during winter and spring runoff events. Promote synchronization of ecological processes between tributaries and the mainstem Trinity River.
- Enhance natural cleaning and transport of river gravels by synchronizing tributary flows and Lewiston dam releases. Reduce buildup of sediment at tributary mouths, enhancing tributary and river confluence functions.
- Reduce cold water releases in spring/summer so the growth of all native aquatic species (fish, their prey, and wildlife) will benefit. The negative impacts from cold water releases in the spring, including the suppression of salmonid metabolism, the disruption of foothill yellow-legged frog breeding, and the indirect impacts of reduced growth rate of prey (macroinvertebrates) in the river, would be reduced.

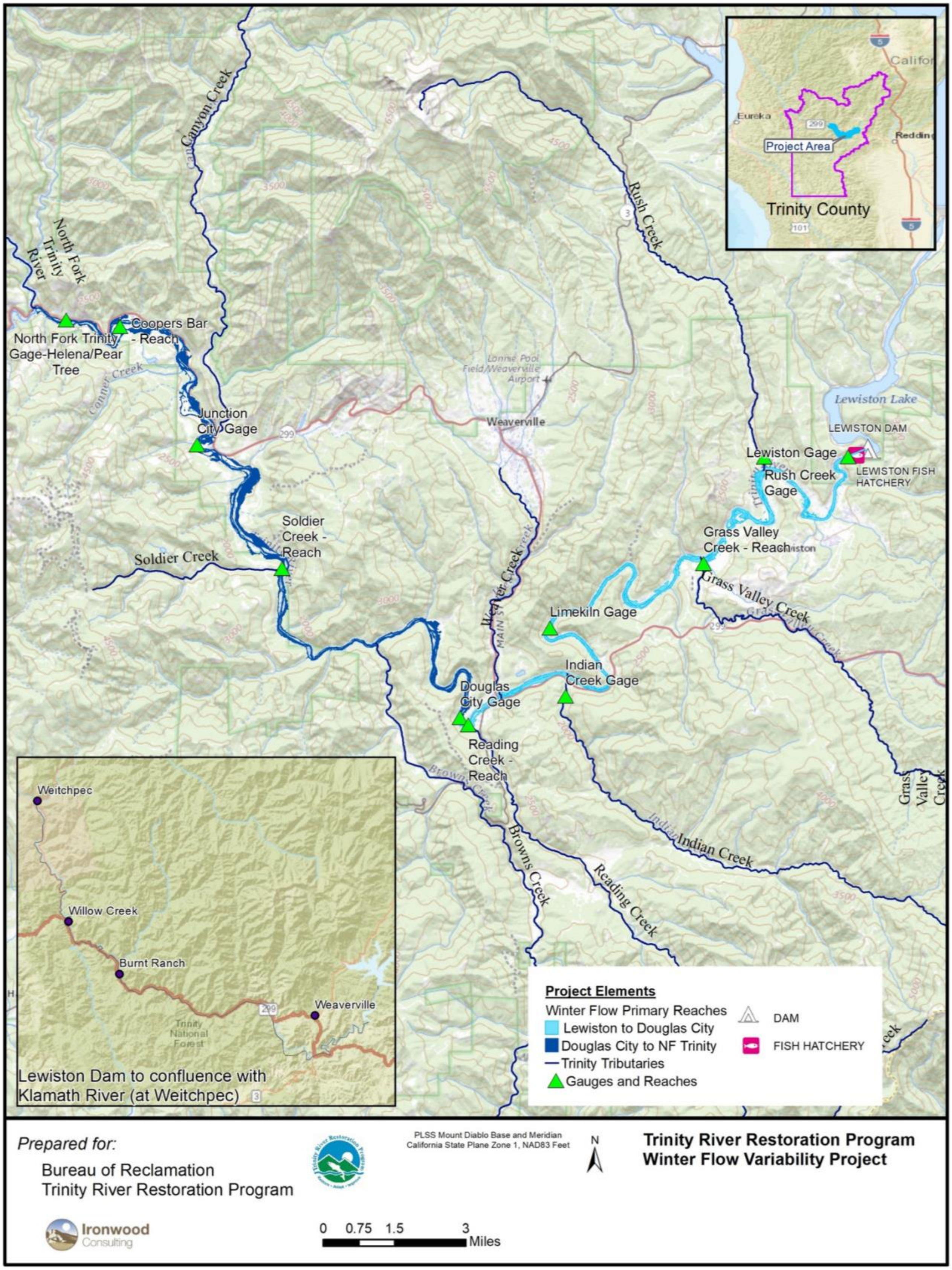

Figure 1-1. The Restoration Reach of the Trinity River, Trinity County, CA.

- Allow the river to naturally warm earlier in the season to provide the proper environmental cues that smolts rely on to time their outmigration to the ocean.

- Increase food availability for salmon fry through earlier production of macroinvertebrate prey species. Increased winter and early spring flows would inundate shallow floodplains that support rooted plants and periphyton and promote macroinvertebrate production earlier in the season, which would in turn be available for consumption by emerging salmon fry.

- Inundate naturally occurring and Program-created floodplains and other productive off-channel rearing habitats prior to fry emergence. Provide access to relatively warm and productive floodplain nursery habitats after fry emergence and prior to downstream migration.

These anticipated benefits can also be used as measures of success after implementation. Outcomes of the Winter Flow Project are anticipated to support longer periods of nursery habitat inundation while juvenile fish are present, increased food availability and forage opportunities, natural warming of river temperatures in early spring, and improved synchrony of bedload transport between the main channel and tributaries. In turn, these more natural conditions are expected to benefit juvenile salmonids and be measurable through increased growth and earlier outmigration of smolts in dry years.

1.2 Trinity River Flow Management and Fisheries Restoration

Congress authorized construction of the Trinity River Division (TRD) of the Central Valley Project (CVP) in 1955 (Public Law 386, 84th Congress, 1st Session). The TRD began operations in 1963, blocking 109 miles of important salmonid habitat above Lewiston and exporting as much as 88% of inflows of the Trinity River into Trinity Lake to the Sacramento River Basin (USFWS and HVT 1999). Fisheries resource managers observed an almost-instantaneous decline in the numbers of naturally produced adult salmonids returning to spawn in the Trinity River basin (declines of 53-96%, depending on the salmonid species) (USFWS and HVT 1999).

To address the precipitous fishery declines, numerous pieces of legislation and a decades-long study led to the completion of the Trinity River Flow Evaluation study by USFWS and Hoopa Valley Tribe (USFWS and HVT 1999) and the subsequent FEIS and ROD. The ROD recognized that salmon recovery required “rehabilitating the river itself” by “restoring the attributes that produce a healthy, functioning alluvial river system” and selected a course of action that included variable annual instream flows, physical channel rehabilitation, sediment management, watershed restoration, and infrastructure improvements guided by an Adaptive Environmental Assessment and Management (AEAM) program.

1.2.1 TRRP History and Purpose

Following the ROD, the U.S. Department of Interior (DOI) established the TRRP to restore the fisheries of the Trinity River affected by dam construction and related diversions. Administered by U.S. Bureau of Reclamation (Reclamation), TRRP is a partnership of federal and state resource agencies, Tribes, and Trinity County. The purpose of the Program is to mitigate impacts of the Trinity River Division of the Central Valley Project on anadromous fish populations in the Trinity River by successfully implementing the ROD and achieving Congressionally mandated restoration goals (www.trrp.net). The long-term goals of the Program are to: 1) restore the form and function of the Trinity River; 2) restore and sustain natural production of anadromous fish populations in the Trinity River to pre-dam levels; and 3) facilitate full participation by dependent tribal, commercial, and sport fisheries through enhanced harvest opportunities (www.trrp.net).

The TRRP is tasked with increasing habitat and river function for all life stages of naturally produced native Trinity River anadromous fish through river rehabilitation projects and dam release management so naturally spawning anadromous fish populations may increase to congressionally mandated levels that existed prior to the construction of Lewiston and Trinity dams. There are many factors that influence returning adult salmon populations, such as ocean and in-river harvest and Klamath River and ocean conditions. For that reason, TRRP's efforts are largely focused on recovery of juvenile salmon and steelhead. The most immediate metric of TRRP success is therefore the number, size and timing of juvenile salmon and steelhead that out-migrate from the Trinity River each year.[1]

The TRRP's strategy is to restore the Trinity River's ecological processes to increase habitat quality and quantity for native anadromous fish. The five primary components of TRRP's river restoration work include:

- Variable annual instream flows – releasing water from Lewiston Dam, based on the water year type, to mimic natural Trinity River flows and interact with downstream areas to enhance conditions for all life stages of fish and wildlife. These variable annual instream flows are also called restoration releases or restoration flows.

- Channel rehabilitation – restoring the functional floodplain of the river, which has been channelized and simplified by managed river flows and mining. To date, the TRRP has constructed 34 of the rehabilitation projects identified in the 1999 TRFES and Trinity River FEIS (USFWS et al. 2000b.[2]

- Sediment management – Introduce sediment to the river to replace gravel and fine sediments trapped behind the dams. Gravel provides spawning areas and other habitat benefits for salmon, macroinvertebrates, and biofilm. Fines provide habitat for lamprey and substrate for riparian plants and promotes conditions that benefit mobility of coarse sediments. TRRP resupplies these sediments to make up for upstream reservoirs capturing sediments that would otherwise be provided naturally to the Trinity River below Lewiston Dam.

- Watershed restoration – addressing negative impacts that have resulted from poor land management in the Trinity River basin. Watershed restoration activities include reducing unnaturally high contributions of fine sediment from Trinity River tributaries, ensuring fish passage to tributary habitat, and creating better aquatic conditions in watershed areas to support stream life.

- Adaptive management – monitoring, evaluating, and improving the effectiveness of river restoration actions through an AEAM program.

[1] Summary of the TRRP fish outmigration statistics are available at: https://www.trrp.net/restoration/adaptive-management/fish-biology/fisheries-monitoring-and-escapement/.

[2] The 2009 Master Environmental Impact Report (EIR) authorizes the TRRP to complete rehabilitation projects and gravel augmentation after NEPA and the California Environmental Quality Act (CEQA) review for individual projects at the project site level. It is available at: https://www.trrp.net/library/document/?id=365.

2. Winter Flow Project Scientific Rationale

2.1 Problem Statement

Flow regulation by dams on many California rivers has caused a distortion of the natural winter-flood, summer-drought hydrograph (Wooton et al. 1996). Consequently, peak winter storm flows, particularly flows that can mobilize riverbed substrates, are much reduced and summer base flows are artificially enhanced (Mount 1995). Flow regulation on the Trinity River after construction of the TRD removed nearly all high flows that were responsible for forming and maintaining the dynamic alluvial river and, notably, scour by winter floods downstream of Lewiston Dam. Operation of the TRD also changed the thermal regime of the Trinity River, providing warmer water temperatures during the winter and colder water temperatures during the late spring/summer because of hypolimnetic releases from Trinity Dam (USFWS and HVT 1999). This results in a cascading impact to salmon populations in the Trinity River. This section provides an overview of these issues and the best available scientific studies to understand the effects of the current restoration releases on the recovery of salmon in the Trinity River.

Variable annual instream flows, referred to as restoration flows or restoration releases, were first implemented by TRRP in 2004. ROD-recommended restoration flow releases attempt to mimic snowmelt hydrology, create a more natural cycle of flow variability, promote alluvial processes, and provide water temperature and habitat benefits for fisheries resources compared to pre-ROD release schedules (TRRP 2013). These restoration releases occur after the water year type is determined in mid-April, based on an approved hydrograph developed by TRRP.[3] Variable releases typically extend to early summer before returning to baseflow conditions and then remain at baseflow until the following April when a new water year is determined.

The ROD as implemented, however, results in the vast majority of annual water volume released after April 15 (Figure 2-1), and a baseflow of 300 cubic feet per second (cfs) for 7 months of the year (October to April), when streams in the region experience their largest and most variable flow events. Undammed tributaries to the Trinity River naturally flow higher during winter storm events and as high elevation snowpack melts in early spring. Thus, natural contributions to the Trinity River from its tributaries are often receding by the time ROD flow releases from Lewiston Dam occur after mid-April.

The asynchrony between flow management and the natural variability of pre-dam flows has cascading impacts on the form and ecology of the river, including impacts to young salmon. Pacific salmon's life history has adapted to the natural seasonal variability of flows for millions of years (Groot and Margolis 1991). Current flow management that keeps river conditions unnaturally cold during spring suppresses metabolic rates during the key period of growth for young salmon. The inundation of rearing habitat, including floodplains, side channels and alcoves constructed by TRRP does not occur until the majority of juvenile salmonids are downstream of the restoration reach (Petros et al. 2017). Later in the spring, the unnaturally cold river delays environmental cues that trigger outmigration by smolts to the ocean before conditions in the lower Klamath become too warm to support salmon migration.

[3] TRRP uses five water year types to determine how much water will be available to the Trinity River each year. The five water year types are: Critically Dry, Dry, Normal, Wet, and Extremely Wet. A wetter water year means more water is available for restoration flow releases. The water year type is determined by the Department of Water Resources' B120 (ca.gov) water supply forecast.

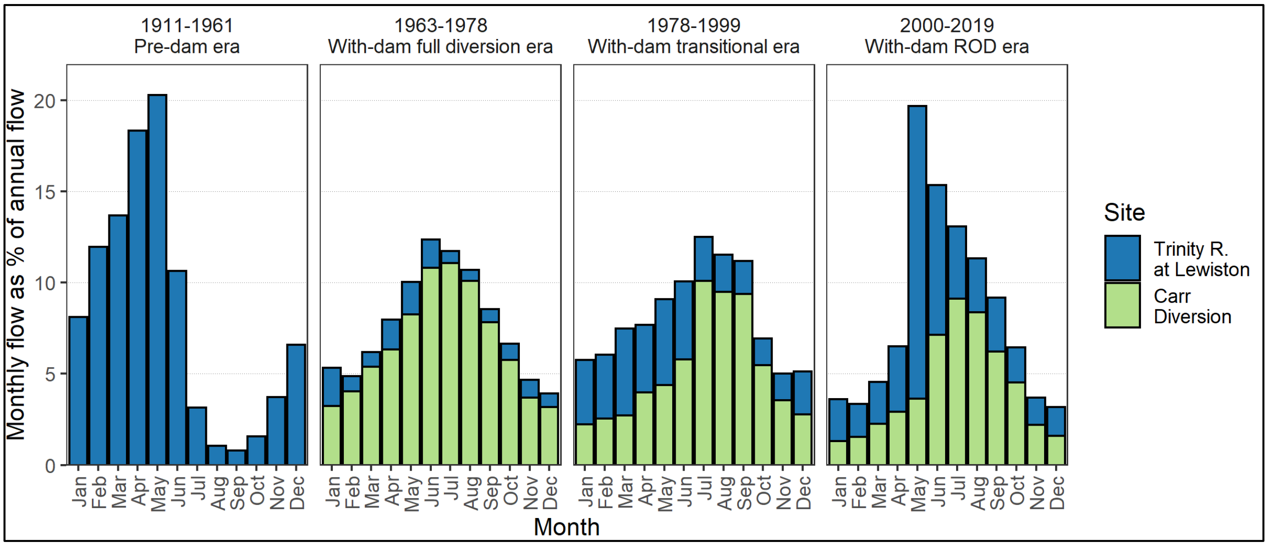

Figure 2-1. Changes to the proportion of water upstream of Lewiston available to the Trinity River over time (Asarian et al. *in review*).

2.2 Temperature

Water temperature is one of the most important variables affecting salmonids and other aquatic organisms (Carter 2005). Temperature influences feeding rates and growth, metabolism, development, timing of migration, spawning and rearing, and the availability of food, which are discussed below.

Water temperatures in the Trinity River are influenced by dam release temperatures, flow rates, and shortwave solar radiation. These variables result in a seasonal gradient associated with the distance downstream from the Lewiston dam. A key objective of the TRRP's flow management is to improve the thermal regimes for all anadromous salmonid species and life stages that use the Trinity River. The TRRP has been using flow management practices to meet specific temperature management targets, and temperature monitoring data have been collected as part of the AEAM.

2.2.1 ROD Restoration Releases and Temperature Suppression

Since the construction of the TRD, discharges from Lewiston Dam have had a significant effect on water temperatures in the Trinity River. Reservoir releases from Lewiston Dam have altered the natural temperature regime, making the river warmer in the winter and colder in the summer than under pre-dam conditions. Depending on the water year type and time of year, this effect diminishes to varying degrees with distance from Lewiston Dam.

The thermal regime issue due to the hypolimnetic releases from Trinity Dam has not been resolved through the implementation of restoration releases, and the impacts in late spring and early summer extend farther downstream due to high magnitude flow releases under ROD management. Modifying the dam to include a temperature control structure or installation of a bulkhead with a multi-level intake structure would come at significant expense and would require more formal studies by Reclamation. Being limited to hypolimnetic releases is an operational reality when implementing variable flows in the Trinity River.

In many regions throughout the US, a positive relationship between stream order and water temperature has been reported, unless the stream has a high baseflow index. In other words, tributaries are generally colder than the body of water they feed (Segura et al. 2015). Due to the cold deep-water releases from Trinity Reservoir after April and the current temperature thresholds imposed by regulatory processes, the mainstem Trinity River is now colder than most, if not all, of the tributaries upstream of the North Fork Trinity River, except at low Trinity Reservoir storage levels. For example, in 2017 (Extremely Wet) and 2018 (Critically Dry) Rush Creek was often 10 degrees Celsius (°C), or 18 degrees Fahrenheit (°F), warmer than the mainstem Trinity River (Figure 2-2).

2.2.2 Temperature Thresholds

Temperature targets are widely used by fishery managers to accommodate the various life stages of Pacific salmonids (Carter 2006). Table 2-1 shows the various temperature "targets" or thresholds for the Trinity River.[4] The Program has worked to meet ROD water temperature objectives and targets for protecting adult salmonids upstream of the North Fork Trinity River (adult holding targets) and out-migrating juvenile salmonids throughout the mainstem river, as measured at Weitchpec (outmigration targets). The adult holding temperature targets are implemented as part of the Water Quality Control Plan for the North Coast Region (Basin Plan) and compliance is monitored by the Regional Water Board. Outmigration temperature targets were developed as part of the TRFES, are currently under review, and will likely be recommended to the TMC for reevaluation and revision in the future.

Reclamation has attempted to maintain water temperature objectives for protecting adult salmonids upstream of the North Fork Trinity River as measured at Douglas City and the North Fork Trinity River (adult holding targets) and outmigrating juvenile salmonids throughout the mainstem river, as measured at Weitchpec (outmigration targets), since its inception in 2000. A recent evaluation of programmatic objectives and targets resulted in a recommendation for an additional temperature objective for rearing juvenile salmonids in the mainstem Trinity River, upstream of and measured at the North Fork Trinity River (rearing target). The rearing target is being evaluated because temperatures during the critical rearing period are a central focus of the proposed action to move ROD water volumes prior to April 1.

The TRRP's Fish Workgroup (Naman et al. 2020) recently recommended utilizing 55.4°F (13° C) to 61.7°F (16.5°C) as rearing temperature targets in the Trinity River upstream of the North Fork Trinity River from April 1 to July 31. This rearing target temperature range is based on the 7-Day Average of the Daily Average temperature, and draws upon research that suggests this is the optimal temperature range for growth (Lusardi et al. 2019).[5] The rearing target is included in this analysis because temperature during the critical rearing period is the central focus to move ROD water volumes prior to April 1 under the Winter Flow Project (Table 2-1).

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[4] Although these temperature values are often considered "objectives" or "targets", they are more accurately thought of as thresholds because any water temperature lower than those in Table 2-1 would comply (Naman et al. 2020).

[5] Lusardi et al. (2019) found that juvenile Coho Salmon growth rates peaked at a mean temperature of 16.6°C and Maximum Weekly Maximum Temperature (MWMT) of 21.1°C and were six times greater than those observed at the coolest reach, which exhibited a mean temperature of 13.0°C and MWMT of 16°C.

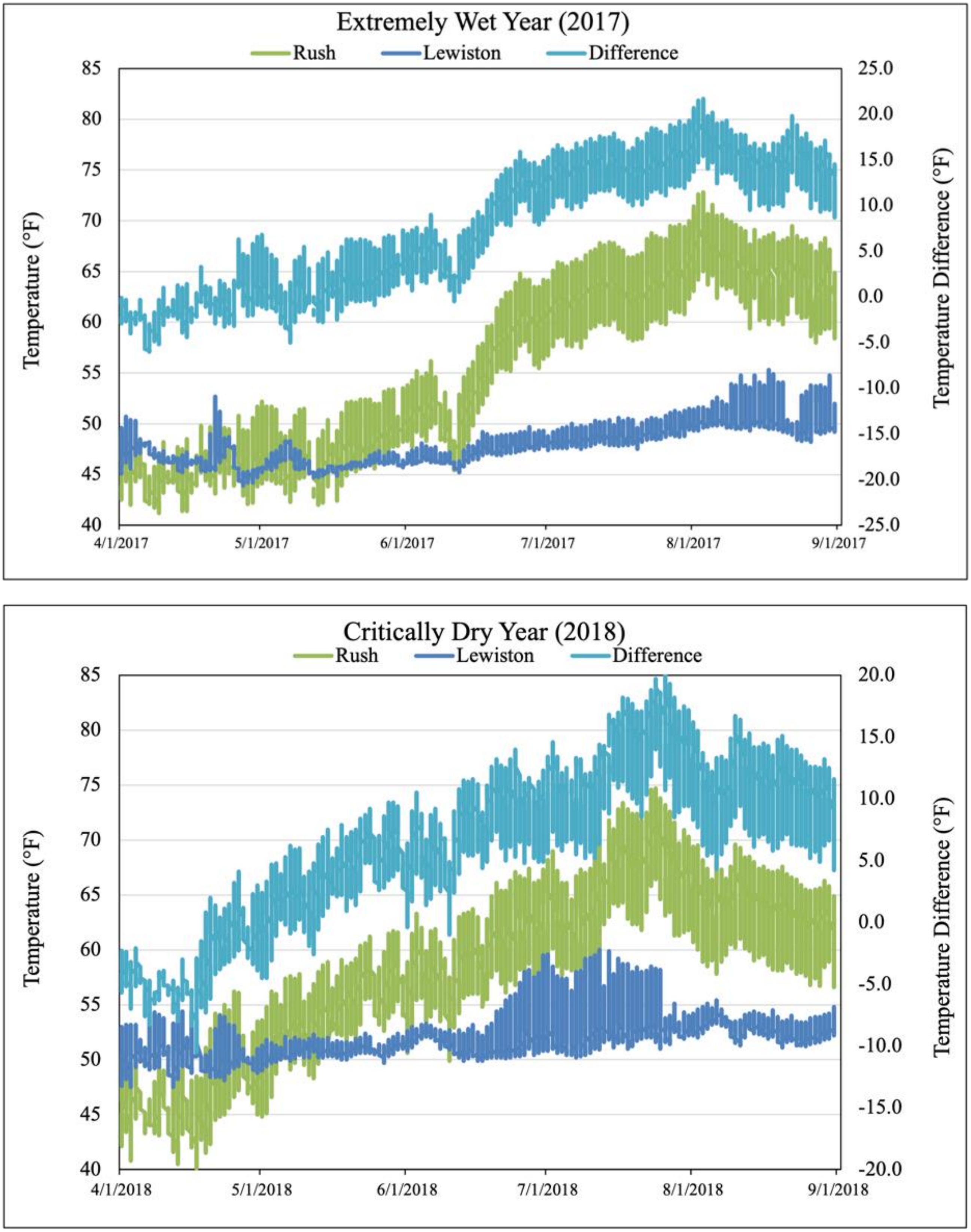


Figure 2-2. Water Temperature (left vertical axis) and Temperature Difference (right vertical axis) of the Trinity River at Lewiston and Rush Creek from April to September of 2017 (an Extremely Wet Year) and 2018 (a Critically Dry Year).

Table 2-1. Temperature targets for adult holding and juvenile rearing.[6]

Source	Reach	Dates	Target
Fish Workgroup Recommended Juvenile Rearing Range (Naman et al. 2020)	North Fork	April 1 – July 31	55.4 - 61.7F (13°C - 16.5°C)
Basin Plan and WR 90-5 (RWQCB 2011)	Lewiston to Douglas City	July 1 – September 15	≤60°F (15.5°C)
	Lewiston to Douglas City	September 15 – 30	≤56°F (13.3°C)
	Lewiston to North Fork	October 1 – December 31	≤56°F (13.3°C)
Springtime Objectives of the ROD for the TREIS/EIR (USFWS et al. 2000a)	Lewiston to Weitchpec	**Normal & Wetter Water Years**	
		April 15 – May 22	≤55.0°F (12.8°C)
		May 23 – June 4	≤59.0°F (15.0°C)
		June 5 – July 9	≤62.5°F (17.0°C)
		Dry & Critically Dry Water Years	
		April 15 – May 22	≤59.0°F (15.0°C)
		May 23 – June 4	≤62.5°F (17.0°C)
		June 5 –July 9	≤68.0°F (20.0°C)

2.3 Salmonid Growth

2.3.1 Effects of Temperature on Growth and Metabolism

Temperature is one of the most important environmental influences on salmonid growth. Most aquatic organisms, including salmon and steelhead, are ectotherms, meaning their temperature and metabolism are determined by the ambient temperature of water (Carter 2006). Warmer water temperatures translates into faster growth for salmonids (Lusardi et al. 2019). Larger Chinook smolts are thought to have a better chance at survival during ocean entry (Pearcy 1992) as well as through the first ocean winter (Beamish and Mahnken 2001).

A defining characteristic of ectothermic organisms, which includes stream invertebrates, amphibians, reptiles, and fish, is their core temperature conforms to ambient temperature. For this reason, the ability to choose the temperature of their surroundings is of particular importance. This ability is referred to as behavioral thermoregulation and impacts an organism's effectiveness to capture and metabolize food (Armstrong and Schindler 2013; Watz and Piccolo 2010), reproduce and develop (Railsback and Rose 1999), and evade predation

[6] The Fish Workgroup's newly proposed juvenile-rearing temperature target is presented as a range, so temperatures below the lower target are considered detrimental in a comparable way to temperatures above the upper target. This juvenile temperature target is warmer than preferred temperatures cited in the TRFES (see Table 5.13 in USFWS and HVT 1999) but is consistent with recent study findings on optimal growth temperatures. With adequate food resources, the newly proposed juvenile rearing temperatures would promote accelerated juvenile fish growth.

(EPA 2001). For example, well-fed salmonids tend to behaviorally thermoregulate in slightly warmer water than conspecifics consuming a lesser ration. The combination of feeding opportunities and warmer water tends to maximize growth. When food is scarce, salmonids will choose cooler water to lower their metabolic rate and conserve energy (EPA 2001). Cold temperatures can reduce the ability of foraging salmonids to capture prey. Watz and Piccolo (2010) found the percent of drifting prey captured by brown trout fell from 96% to 53% when temperatures reduced from 14°C to 5.7°C (57.2°F to 42.3°F).

Elsner and Shrimpton (2019) found a mean temperature preference of Fraser River B.C. Coho Salmon of 16.5°C (61.7°F) for parr and 15.5°C (59.9°F) for smolts. Lusardi et al. (2019) found that Shasta River, California Coho Salmon absolute growth rates peaked at a mean daily average water temperature of 16.6 ºC (61.9°F). Sullivan et al. (2000) found that an Maximum Weekly Maximum Temperature (MWMT) of 13°C to 16.5°C (55.4°F to 61.7°F) would result in no more than a 10% reduction in maximum growth. Railsback and Rose (1999) found that predicted growth for rainbow trout varies with fish size and food consumption, but in general, their model predicted growth to be high between 10°C and 22°C (50°F and 71.6°F), peaking at about 15°C (59°F).

Recent Trinity River water temperatures above the North Fork Trinity River are shown in Figure 2-3, along with the optimal temperature range for juvenile rearing developed by Naman et al. (2020) and recommended by the Fish Workgroup. Note that at the end of April for most water year types, just as the Trinity River begins to achieve the recommended targets in the optimal rearing range for juvenile salmonids, a 9°C to 12.6°C (5°F to 7°F) reduction in temperature reduction in temperatures occurs coincident with the onset of TRRP restoration flow releases from Lewiston Dam. In some cases, water temperatures are nearly 10°C (18°F) less than the recommended juvenile salmonid rearing temperature range. This is due to the large volume of water that is released annually from Lewiston Dam in accordance with TRRP restoration flow releases, as discussed above.

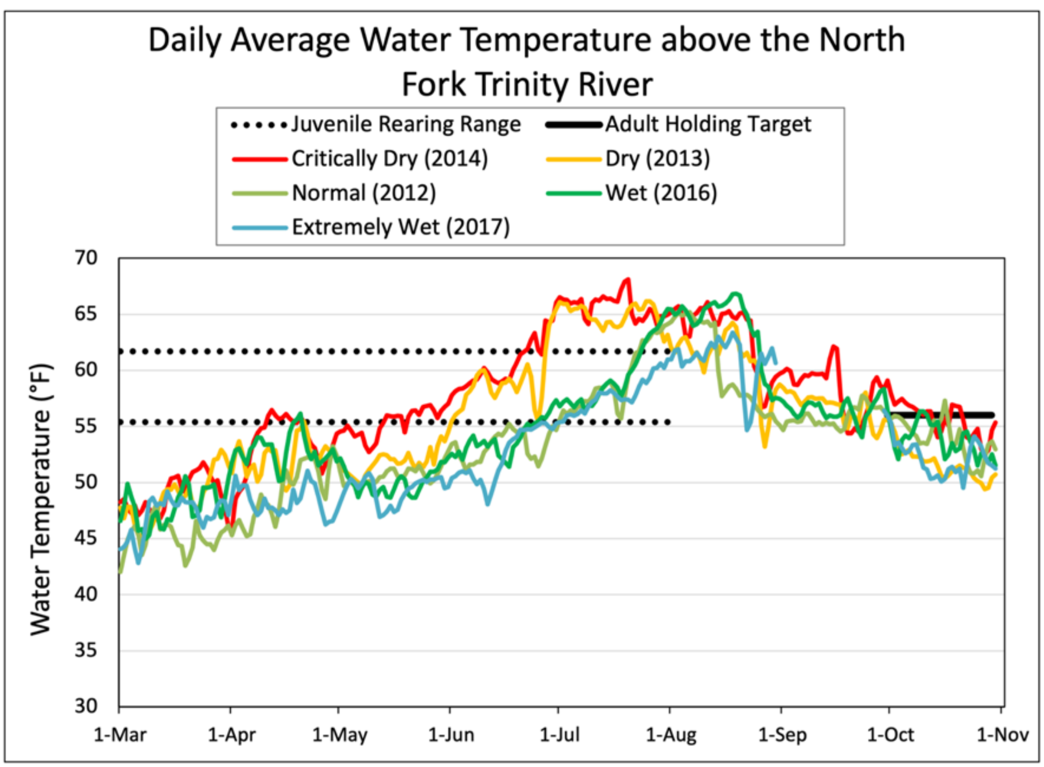


Figure 2-3. Water temperatures for one of each of the five water year types in the Trinity River above the North Fork Trinity River (Naman et al. 2020).

Consistently low water temperatures are assumed by most fishery managers to be either positive or at least not harmful; however, as discussed above, cold water during juvenile rearing periods can limit fish growth (Lusardi et al. 2019). A recent study by Armstrong et al. (2021) illustrates the potential synergy between seasonally warm and perennially cool habitats, with fish that traverse these two types of thermal habitat growing more than fish that were restricted to either habitat. Seasonally warm thermal habitats are largely unavailable on the Trinity River until floodplains are inundated by ROD restoration flows in mid-April, which is discussed in more depth in Section 2.4 . Diverse juvenile rearing temperature conditions may increase outmigrant growth in the Trinity River, consistent with recent study findings by Lusardi et al. (2019).

Figure 2-4 depicts the temperature dependence function for Chinook Salmon for the normal range of temperature recorded at the Pear Tree/Helena station during the modeling period (2005-2016) used by Thomas Gast & Associates (2021). The highest proportion of the maximum potential consumption (Cmax) is achieved at or above15°C (59°F). The proportion of Cmax (pCmax) that a Chinook can consume at 5°C is approximately a third of that at 15°C (59°F). Consumption does not translate directly into growth since additional energy is required for metabolism, egestion, and excretion; however, the maximum potential for growth does occur at the temperatures where Cmax is near 1.0 (Thomas Gast & Associates 2021).

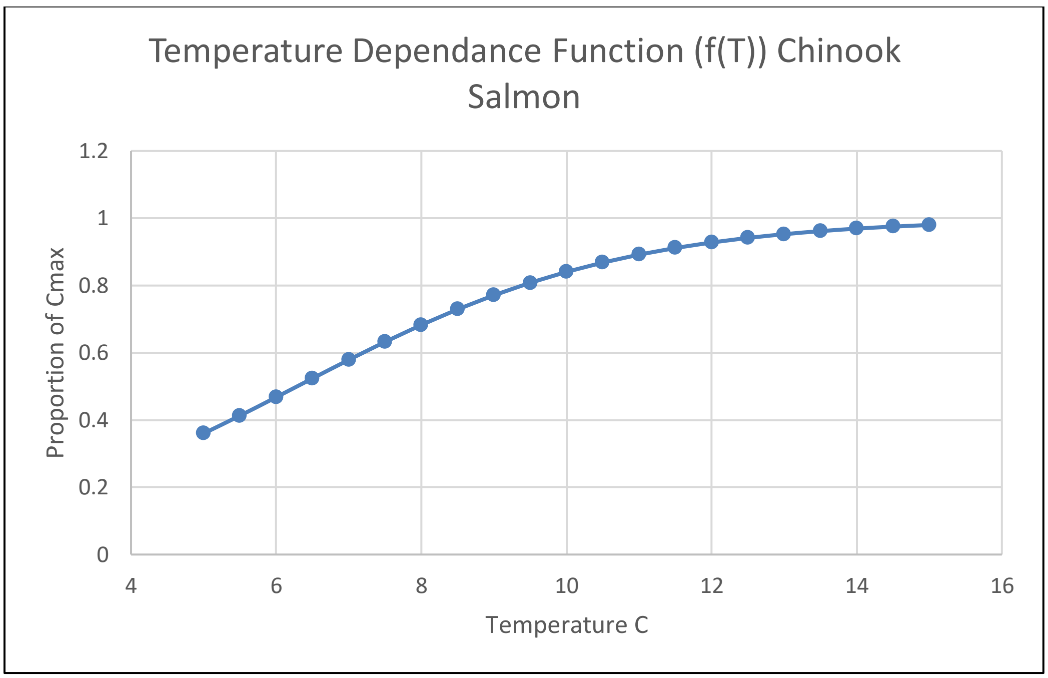


Figure 2-4. Temperature dependence function for Chinook Salmon for the normal range of temperature recorded at the Pear Tree/Helena station during the 2005-2016 modeling period (Thomas Gast & Associates 2021).

To further illustrate how hypolimnetic releases post-ROD have negatively influenced stream temperatures, Figure 2-5 demonstrates the effect of cold-water suppression on juvenile fish caught in the Willow Creek rotary screw trap by Julian week (Pinnix 2021). Individual fork length values were pooled by week of the year across the pre-ROD (1989-2003) and post-ROD (2004-2018) periods for the Willow Creek trap site to create pre-ROD and post-ROD time series of mean weekly fork length of non-adipose fin-clipped age-0 Chinook Salmon. Only weeks of the year 10-39 (approximately March through September) were used as this is prior to the October release of hatchery fish. Comparisons of fork length at Willow Creek pre-ROD versus post-ROD showed significant differences pre-ROD versus post-ROD in most weeks. Post-ROD fork length was

significantly larger than pre-ROD in weeks 13, 15, 16, and 18 (approximately April through early May). Pre-ROD fork length was significantly larger in weeks 20, and 22 through 36 (approximately May through mid-September). Week 20 correlates to the calendar month of May which has the highest release volumes post-ROD. In both pre-ROD and post-ROD periods, fork length increased significantly in week 23 and 24 (approximately mid-June) due to the arrival of unmarked hatchery fish.

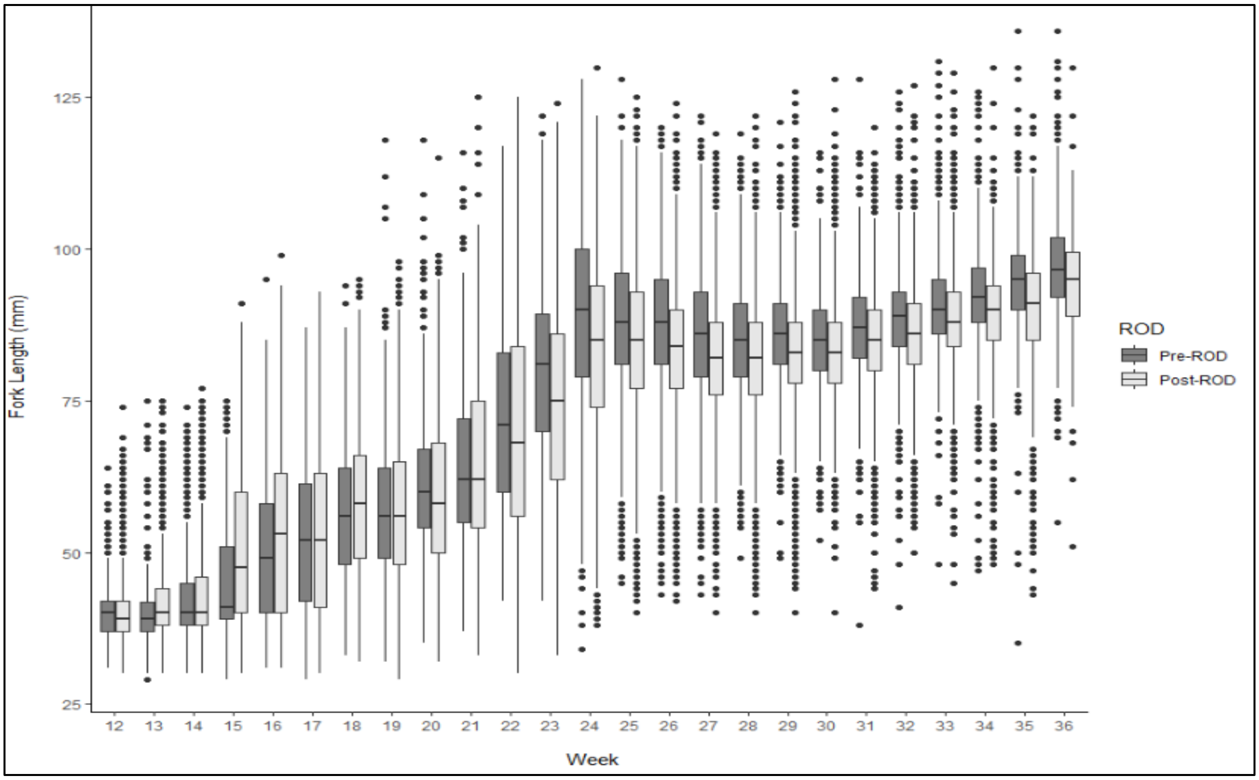


Figure 2-5. Box plot of non-adipose fin-clipped age-0 Chinook Salmon captured at the Willow Creek trap site grouped by week and ROD period (Pinnix 2021).

2.3.2 Flow, Population Density, and Growth

Thomas Gast & Associates (2021) developed a multiple regression model to assess the influences of population density and river flow on the total consumption by juvenile Chinook Salmon trapped at Willow Creek rotary screw trap in week 22 (approximately late May / early June), as predicted by the bioenergetics simulations (2005 through 2016). The results shown in Figure 2-6 suggest that higher discharge in February, March and April positively influences consumption, whereas the number of redds and discharge in May negatively influence consumption. Discharge in April (+), discharge in May (-), and number of redds (-) were the most important factors. Including Year as a factor, either as a random or fixed effect, did not improve this model (likelihood ratio tests; p=0.158 and p=0.635), indicating that changes in consumption over time were best explained by the discharge by month and number of redds.

The study's findings indicate that the number of redds the previous fall negatively influences modeled juvenile length frequency at week 22 (Figure 2-6 and Figure 2-7). The redd count variable is negatively associated with run timing in the multivariate models. It is possible that these negative associations of redd counts with juvenile length and outmigrant timing are density-dependent effects associated with increased competition for food and habitat resulting from the higher population (Thomas Gast & Associates 2021).

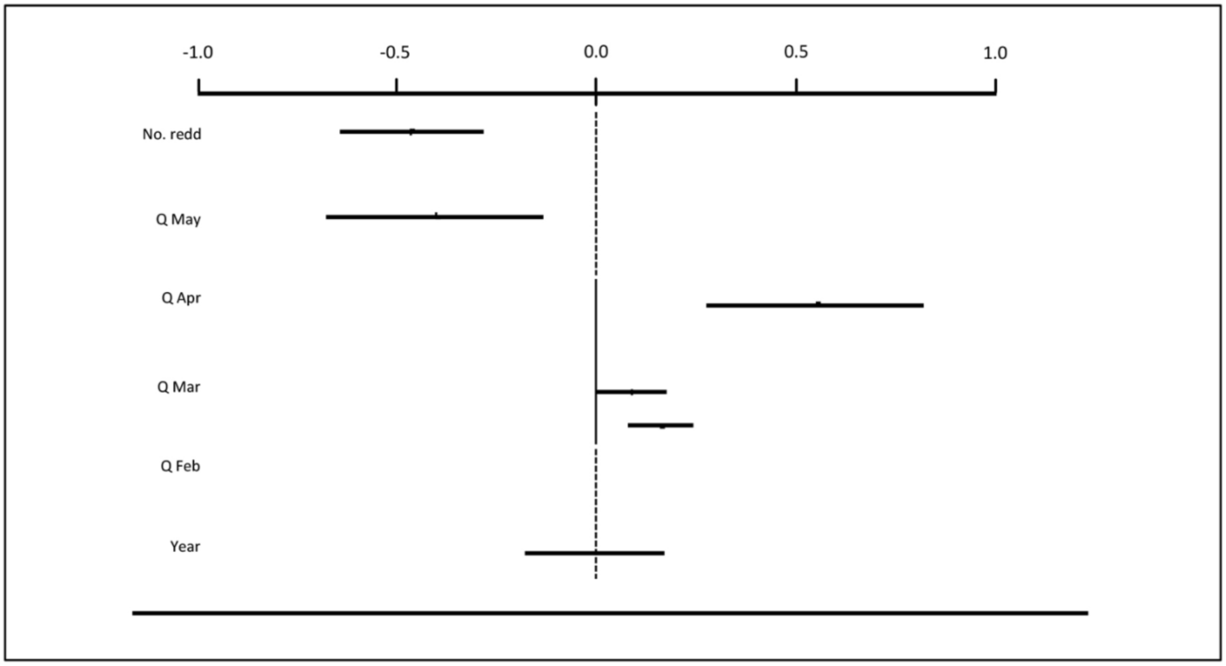


Figure 2-6. Coefficient plots showing the value of the standardized regression coefficient ± 2 SE for each fixed effect included in the generalized linear mixed model for describing changes in juvenile Chinook Salmon consumption, along with the 95% confidence interval for fixed effects (Thomas Gast & Associates 2021).

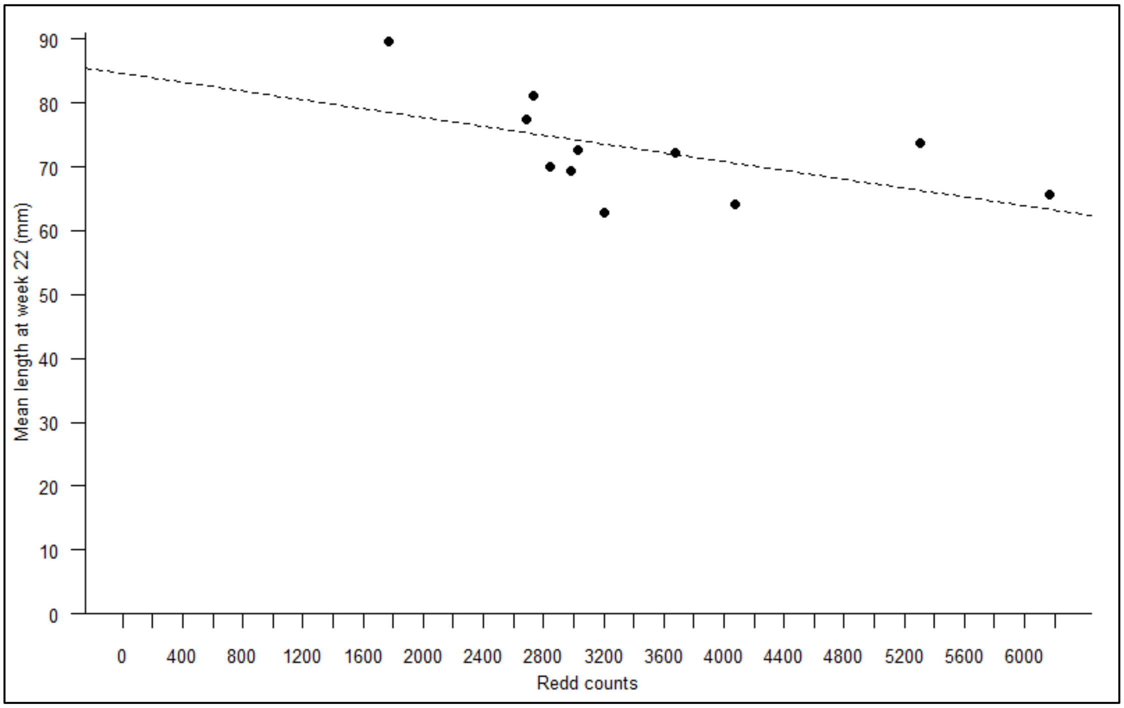


Figure 2-7. Relationship of mean fork length of juvenile Chinook Salmon caught at the Willow Creek rotary screw trap and Trinity River redd counts, R2=0.31, p=0.026 (Major axis, regression type 2 tested with 9999 permutations; 2006 was excluded; Thomas Gast & Associates 2021).

2.4 Habitat Availability

Current spring restoration releases under the ROD have resulted in underutilization of naturally occurring and TRRP-created rearing habitat by juvenile fish. This is because lateral gains in rearing habitat occur when discharge increases and overspills from the river channel to the surrounding margins and floodplains. Under the current flow regime, inundation of rearing habitat within the floodplain occurs after most of the fish have left the restoration reach. Table 2-2 shows a comparison of the percent of juvenile Chinook Salmon outmigration at the Pear Tree rotary screw trap by February 1 and the percent of juvenile Chinook Salmon that have outmigrated by the time that spring flow releases occur (Petros et al. 2017).

From 2003 to 2016, an average of 60% (with a range of 49% to 87%) of salmonids had reared and outmigrated from the restoration reach prior to the April restoration releases (Petros et al. 2017). Under the current release framework, most juvenile Chinook Salmon are not able to access productive floodplains that provide habitat with low velocity, ample forage, cover, and warmer temperatures known to bolster growth of juvenile salmon (Sommer et al. 2005). In addition, the majority of native fish are unable to take advantage of increases in drift forage opportunities within the restoration reach that can occur with changes in discharge during early rearing because they are no longer present.

Table 2-2. Comparison of percent juvenile Chinook Salmon outmigration at Pear Tree rotary screw traps by February 1 and the percent juvenile Chinook outmigration by onset date for spring flow releases above winter baseflow (Petros et al. 2017).

Year	Percent Outmigration (February 1)	Spring Flow Restoration Release Date	Percent Outmigration by Release Date
2003	14%	April 30	74%
2005	14%	April 22	72%
2006	0%	April 12	50%
2007	0%	April 27	53%
2008	1%	April 23	46%
2009	2%	April 27	50%
2010	8%	April 23	62%
2011	14%	April 22	58%
2012	1%	April 21	49%
2013	5%	April 21	53%
2014	0%	April 23	47%
2015	16%	April 22	83%
2016	46%	April 21	87%
Averages	**9%**	**April 22**	**60%**

2.5 Food Availability

Scouring flows in lotic systems have ecological effects on biota and play a strong role in species assemblage and succession (Power et al. 2008). Species have variable adaptation to disturbance patterns and respond and recover differently. Current flow management on the Trinity River provides steady low flows during the salmonid spawning, incubation, and early rearing periods. While high flows that scour the channel bed occasionally occur

below major tributaries on the Trinity River, present day floods occur far less frequently and are of lower magnitude than prior to construction of the TRD. Flood suppression by dam operations is thought to be protective of the early life stages of salmon, but current management largely neglects assessment of the beneficial effect of floods on non-salmonid stream biota, on which salmon rely.

River food webs benefit from riverbed scour caused by flood disturbance (Wooton et al. 1996; Parker and Power 1997). Shortly after flood scour, stream insects are dominated by fast-growing taxa (e.g., chironomids and mayflies) vulnerable to predation by juvenile fish (Parker and Power 1997). These early successional species are reduced over many months as larger, slow-growing taxa, which are less vulnerable to predation by fry, increase contributions to invertebrate assemblages and reduce salmonid prey availability (Parker and Power 1997).

Periodic channel bed scour is an objective of spring variable flow releases on the Trinity River, but the timing of these scour events (often in May) might not support temporal prey availability when juvenile fish are present in the upper river. While these disturbance events have similar benefits in recruiting land-borne nutrients to the system and resetting primary production, increases in species productivity and drift foraging are mostly beneficial in the near term. Peak densities of juvenile salmonid prey species (e.g., chironomids) have been shown to be higher in ephemeral habitats continuously inundated between 5 and 10 weeks (Merz et al. 2012). A study of food web response following a controlled flood on the Colorado River found that concentrations of invertebrate drift forage increased 148% in the months following disturbance (Cross et al. 2011), but changes in drift forage, like primary succession following disturbance, is most impactful to food availability in the short-term.

It is unclear the extent to which the asynchrony between natural hydrology and ROD flows to generate flooding and scour impacts the overall macroinvertebrate assemblage and biomass on the Trinity River, but it is likely that juvenile fish cannot take advantage of the short-term responses in primary production and increased drift forage that often occur prior to and during emergence in unregulated systems. As discussed in Section 2.2 hypolimnetic releases from the TRD artificially lower water temperature, which increases the generation time of important prey species. Chironomidae generation time drops from 36 days to 25 days when water temps are doubled from 7.5°C to 15°C (45.5°F to 59°F), with mayfly (baetidae) generation time dropping from 250 days to fewer than 100 days (Asarian et al. *in review*).

2.6 Outmigration Timing

The Willow Creek outmigrant trap on the Trinity River has been operated annually since 1989. It was installed and continues to be operated primarily to assess outmigration timing and duration of salmonids, particularly Chinook Salmon. Hayden and Heacock (2014) developed the HDAT Model that models RT80 (when 80% of the Chinook juveniles have passed the trap) based on accumulated daily averaged water temperatures in Hoopa. In quantifying the predictive ability of the HDAT Model, Thomas Gast & Associates (2021) found the best single variable explanatory model tested for RT80 used a threshold accumulated daily average thermal unit (ATU) from the Pear Tree temperature time series. The Pear Tree site is further upstream where the water temperature is colder than at Hoopa and may be more indicative of the temperature that initiates outmigration. These analyses suggest that warmer water temperatures during the initial time of the ROD-flows would encourage earlier outmigration (Thomas Gast & Associates 2021).

2.7 Redd Scour

A perceived concern for implementing peak flow releases during the winter rainy season is predicting the potential scouring of spawning redds downstream of Lewiston dam. To address this issue an understanding of the

relationships among river discharge, bed mobility, and scour depths in areas of the streambed heavily utilized by spawning salmon is required (May et al. 2007). At Sheridan Bar near Junction City, spatial patterns of bed mobility based on model-predicted Shields stress show that a zone of full mobility is restricted to a central core along the thalweg, which spreads with increasing flow strength (May et al. 2007). Statistical analysis indicates that redds are preferentially located in shallow, high velocity areas with relatively coarse substrate near streambanks. These site selection preferences correspond to areas of the streambed that are least likely to become mobilized or risk deep scour during high flow events because the bed is not fully mobile, and the scour potential line does not exceed the average depth to the top of the egg pocket (23 cm, 9.1 in) (May et al. 2007).

Evenson (2001) measured egg pocket depths on the Trinity River using freeze core sampling and documented an average depth of 23 cm (9.1 in) to the top of the egg pocket, and an average of 30 cm (11.8 in) to bottom of the egg pocket. Results from 268 scour chain measurements indicate that scour was not widespread and was rarely deep enough to result in redd scour at the range of flows experienced during the study (May et al. 2007). The study indicates that Chinook Salmon are well adapted for reproductive success in flood-prone systems (May et al. 2007) and increases in flows from Lewiston Dam in the winter months would not negatively impact Chinook Salmon redds. Potential for redd scour under the Winter Flow Project is evaluated in Section 4.5.

3. Winter Flow Project Methodological Approach

3.1 Objectives of the Winter Flow Project

To address the cascading impacts on the Trinity River's form and ecology and the detrimental impacts to young salmon outlined in Section 2, the TRRP and its partners have developed the Winter Flow Variability approach outlined in this section. This approach is based on the principles of adaptive management and directly addresses negative impacts that result from the asynchrony between flow management and the natural variability of pre-dam flows on the Trinity River's form and function, including effects on temperature, salmon growth, habitat and food availability, and the timing of juvenile salmon outmigration.

The Winter Flow Project would be an initial action to refine the timing of restoration flows using the principle of AEAM to meet the geomorphic, fish habitat, temperature, and floodplain habitat objectives of the ROD by:

- Timing restoration releases from Lewiston Dam to better match natural flow variability and tributary accretions during winter and spring runoff events
- Increasing access for fish to productive areas like floodplains and providing seasonally appropriate disturbance of the macroinvertebrate prey species for rearing salmonids by providing water volume to augment winter / early spring flows
- Reducing effects of temperature suppression on growth of rearing juvenile salmonids caused by high magnitude dam releases in the late spring / early summer
- Increasing the efficiency and magnitude with which restoration flows perform geomorphic change in the river channel by synchronizing one or more geomorphic flow releases from Lewiston Dam when tributary runoff events are likewise delivering sediments to the mainstem
- Providing thermal cues for smoltification and downstream migration earlier in the year by allowing the river to warm earlier, thus increasing the chances that smolts will leave the Trinity River prior to the deterioration of environmental conditions in the lower Klamath River

3.2 Baseline Conditions Under the Trinity River FEIS and ROD

Section 1 of the Trinity River FEIS Implementation Plan (Stalnaker and Wittler 2000) outlines the methods Reclamation uses to implement the ROD volumes and restoration flows. Reclamation provides the TMC with a preliminary estimate of the water year classification in early February. The TMC then formulates a preliminary schedule, or hydrograph, for the instream fishery release to the Trinity River and submits it to Reclamation for operational planning. Final decisions on the designation of the water year type are based on the April 1 runoff forecast, which projects inflow to Trinity Reservoir for the water year (October 1 through September 30) determined by the Bulletin 120 (B120) 50% exceedance forecast that is issued by the California Department of Water Resources (DWR).[7] Typically, by April 15 of each year, the TMC provides a schedule for the instream fishery release from Lewiston Dam for consideration by the DOI co-lead agencies (Reclamation and USFWS). Once approved, Reclamation operates the TRD to the proposed schedule as close as operationally possible. Reclamation continues to provide annual instream flows below Lewiston Dam in accordance with the

[7] The B120 forecast is available at https://cdec.water.ca.gov/snow/bulletin120/

recommendations of the TMC and Flow Workgroup, as outlined in the Trinity River FEIS Implementation Plan (Stalnaker and Wittler 2000).

Per the ROD, the total volume of water released from the TRD to the Trinity River ranges from 369,000 acre-feet (af) to 815,000 af, depending on the annual hydrology (water year type) determined as of April 1 of each year (see Table 3-1 and ROD [Appendix B]). Based on subsequent monitoring and studies guided by the TMC, the schedule for releasing water daily, according to that year's hydrology, is adjusted but the annual flow volumes established in Table 3-1 do not change.

Most of the annual water volume continues to be released after April 15 (see Figure 2-1), and a baseflow of 300 cfs is maintained for 7 months of the year (October 15 until ROD flow initiation, which typically occurs around April 15). The annual flow regime continues to follow this pattern, which is detailed in the Trinity River FEIS.

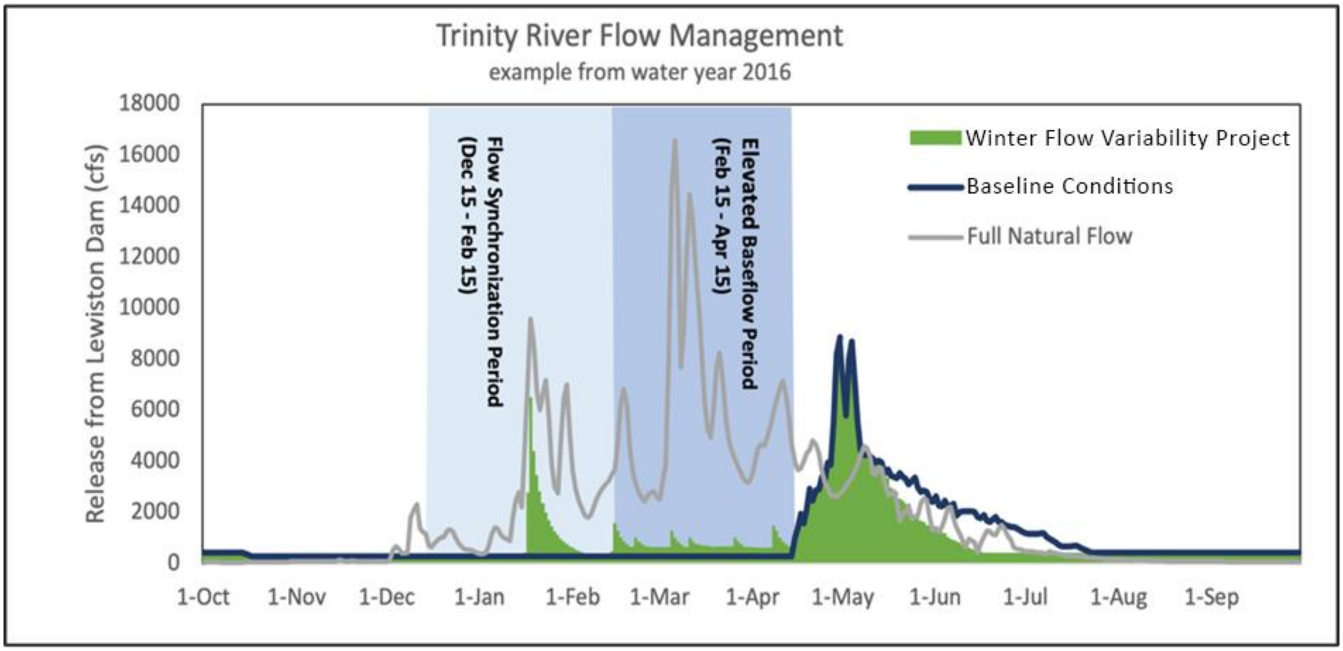
Table 3-1. ROD water volumes by water year class, Trinity Reservoir inflow (af), and ROD water volume (af) allocated based on reservoir inflow, as determined by the April 1 B120 forecasted inflow.

Water Year Class	Trinity Reservoir Inflow (af)	ROD Water Volumes (af)
Critically Dry	< 650,000	369,000
Dry	650,000 -1,024,999	453,000
Normal	1,025,000 - 1,349,999	647,000
Wet	1,350,000 - 1,999,999	701,000
Extremely Wet	≥ 2,000,000	815,000

3.3 Winter Flow Project

The Winter Flow Project would shift a portion of ROD flows to the winter period to better-mimic natural flow variability, inundate rearing habitats prior to fry emergence, reduce cold water suppression of juvenile salmonid growth in spring and early summer, create seasonally appropriate scour to promote primary production and drift foraging opportunities for juvenile fish, and encourage earlier outmigration. Under the Winter Flow Project, Reclamation would shift a portion of the ROD water for release during the winter to two distinct periods termed the Flow Synchronization Period and the Elevated Baseflow Period. Figure 3-1 shows an example of what a hypothetical water year hydrograph under the Winter Flow Project would look like, using the Wet water year 2016 as a comparison to the baseline conditions. Figure 3-1 also graphs the full natural flow[8] from the 2016 water year to illustrate when peaks in flow would have naturally occurred prior to dam construction.

[8] The full natural flow is the unimpeded contributions from the blocked watershed area above Lewiston Dam. It shows the timing of when water would have naturally been contributed to Trinity River if not impounded by Trinity Lake.



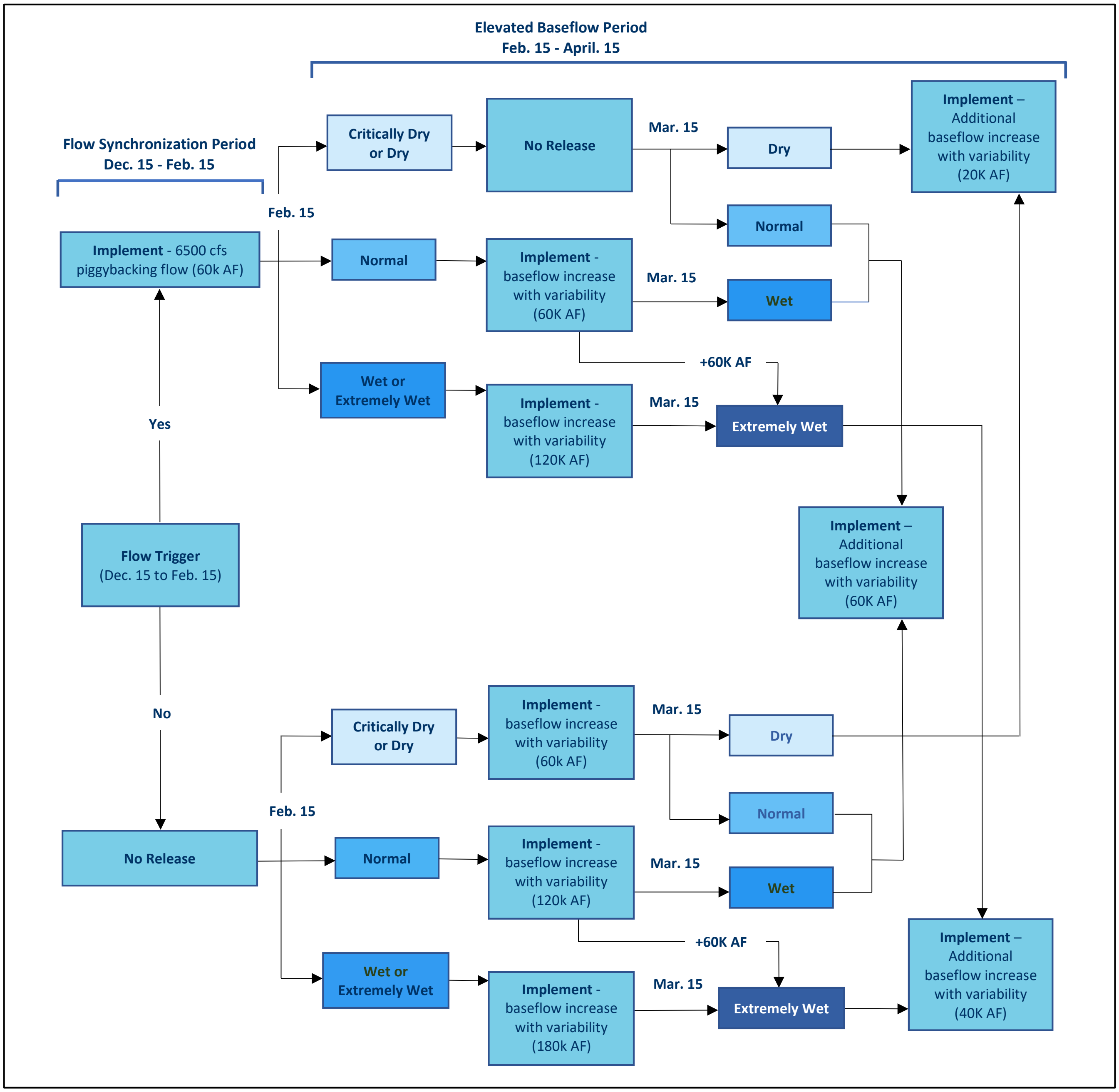
Note: The blue line represents the hydrograph that was implemented in 2016. Green represents the timing of hypothetical water releases that could occur under the Winter Flow Project. The grey line represents the full natural flow.

Figure 3-1. The Winter Flow Project compared to baseline conditions, using the 2016 Wet water year as an example.

Under the Winter Flow Project, the flow releases from Lewiston Dam would remain within the ROD-authorized water volumes outlined in Table 3-1. A hydrograph determined by the TMC and approved by Reclamation and USFWS would continue to be implemented based on the water year determination in April, but the schedule of restoration releases would be expanded so additional winter releases could occur beginning as early as December 15 each water year. Under Winter Flow Project, flows in the Trinity River during summer and winter baseflow periods would not fall below the minimum ROD flows of 450 cfs in summer and 300 cfs in winter, and the volumes to be shifted to the winter and early spring are in addition to the 300 cfs winter baseflow release volume.

Note: The Decision Tree for the Winter Flow Project shows Flow Triggers releasing 60 thousand acre-feet (TAF) in Critically Dry years, 80 TAF in Dry years, 120 TAF in Normal years, 180 TAF in Wet years, and 220 TAF in Extremely Wet years prior to April 15.

Figure 3-2 outlines the decision tree for determining the timing and volume of restoration flow releases under the Winter Flow Project. Hydrographs used for analysis of the Winter Flow Project were developed using historic hydrology from water year 2004-2019, the decision tree process, and hypothetical hydrograph components created to meet the objectives of the Winter Flow Project using water volumes that would be made available throughout the Synchronization and Elevated Baseflow Period. ROD water volumes remaining after April 15 were distributed to meet ROD management objectives and the objectives of the Winter Flow Project. The redistribution of these flows incorporates insights gained through adaptive management, including the benefits to fisheries from shifting scheduled geomorphic peaks earlier and for a shorter duration, and incorporates riparian recession rates to meet ROD objectives through efficient use of remaining volumes.



Note: The Decision Tree for the Winter Flow Project shows Flow Triggers releasing 60 thousand acre-feet (TAF) in Critically Dry years, 80 TAF in Dry years, 120 TAF in Normal years, 180 TAF in Wet years, and 220 TAF in Extremely Wet years prior to April 15.

Figure 3-2. Decision Tree for Winter Flow Project.

Example hydrographs using the methods described in Figure 3-2 for each post-ROD year between 2004 and 2019 are included in Figure 3-3 through Figure 3-6. The hydrographs used for analysis of the baseline conditions were developed from the historic record of releases from Lewiston Reservoir for the water years 2004 through 2019. The hydrograph for each water year illustrates the Trinity River flows at baseline conditions, Winter Flow Project, and the "full natural flow" or un-dammed conditions. This set of hydrographs represents the complete historic record and range of implementation of full ROD water volumes through 2019. All flow releases not attributed to ROD water volumes (e.g., dam safety, ceremonial releases) were removed. The 2004 hydrograph is the first year that the Trinity River ROD was implemented, and 2019 is the most recent year that data are available for analysis.

The water year for ROD volumes is determined by the April 50% B-120 forecast and not the actual water year determination in September. Each hydrograph represents one water year and shows the preferred threshold flows for recreation activities, including shore and wade fishing (300 cfs to 800 cfs), boat fishing (200 cfs to 1,500 cfs), and recreational boating (500 cfs to 4,000 cfs). The water year type (Normal, Dry, Wet, Critically Dry, Extremely Wet) is denoted on the top of each hydrograph.

These hydrographs demonstrate that ROD objectives (i.e., the magnitude or peaks of the restoration releases) can still be met under the Winter Flow Project by shortening the duration of the peak or truncating the receding limb of the historic hydrograph. For example, in the hydrograph for water year 2016 (Figure 3-6), shifting water to the winter period while maintaining peak flows after April was accomplished by truncating the receding limb so that the river returned to 450 cfs summer baseflow by mid-June instead of the beginning of August.

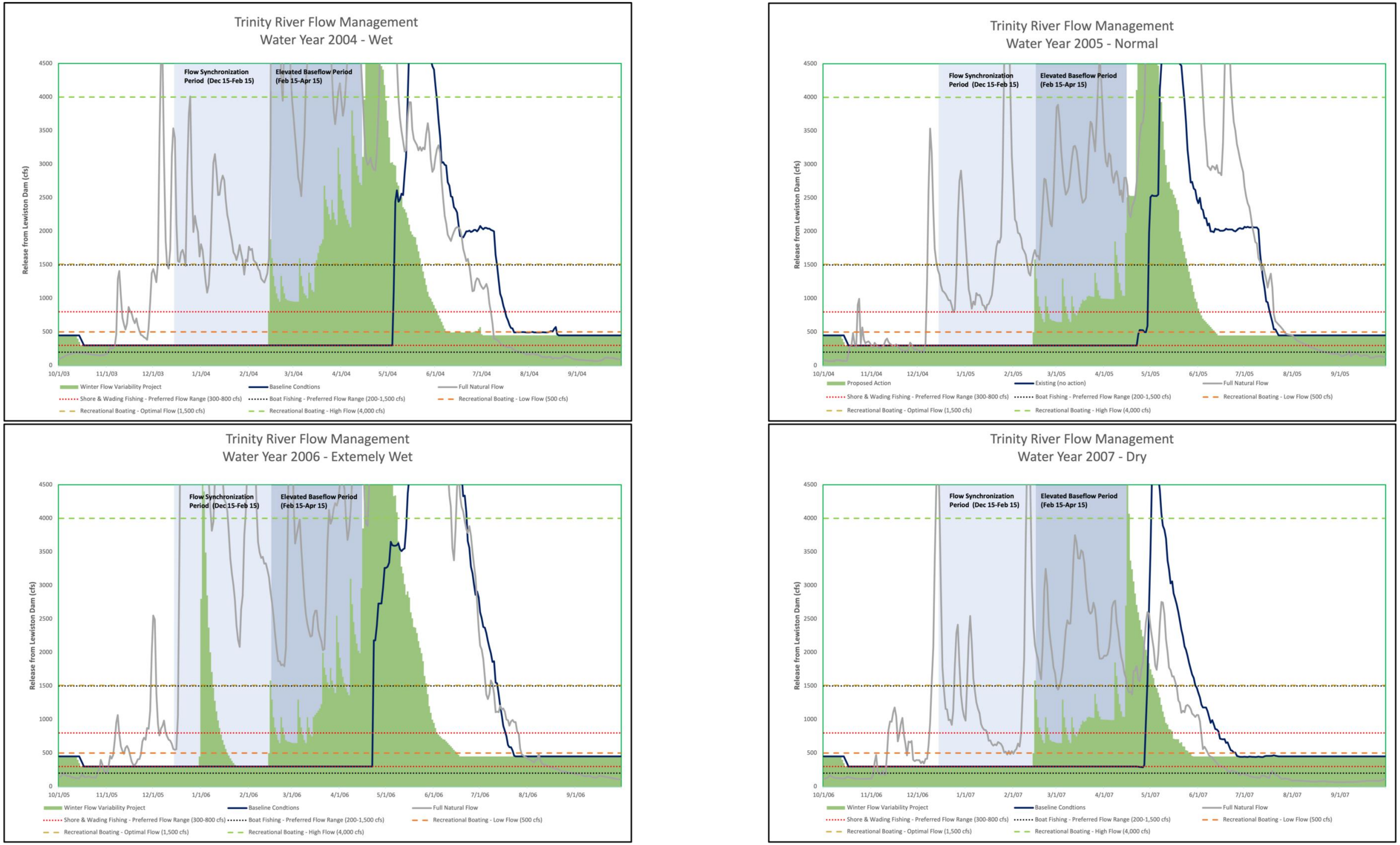


Figure 3-3. Trinity River hydrographs showing the baseline conditions, Winter Flow Project, and free flowing conditions for Water Years 2004 through 2007.

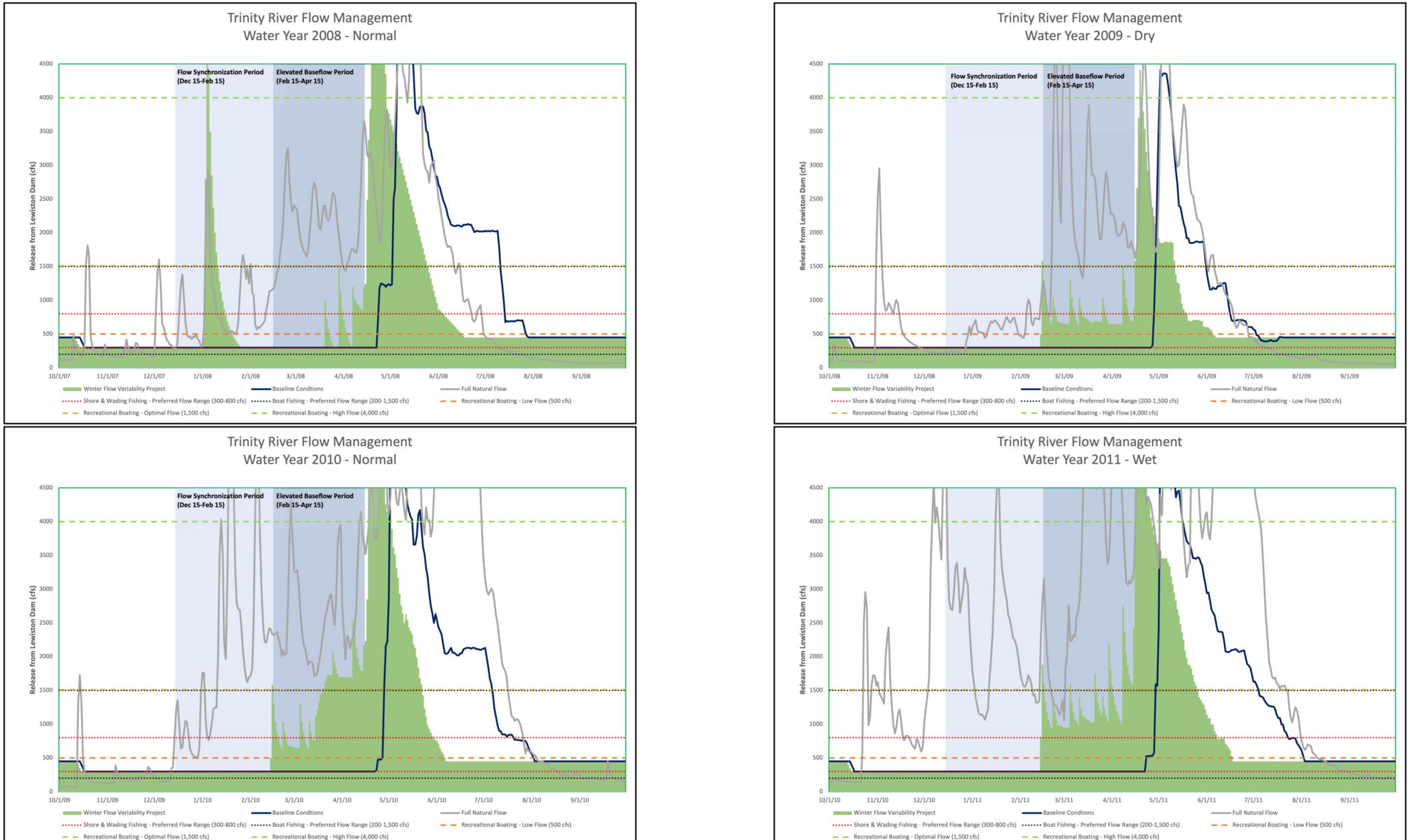


Figure 3-4. Trinity River hydrographs showing the baseline conditions, Winter Flow Project, and free flowing conditions for Water Years 2008 through 2011.

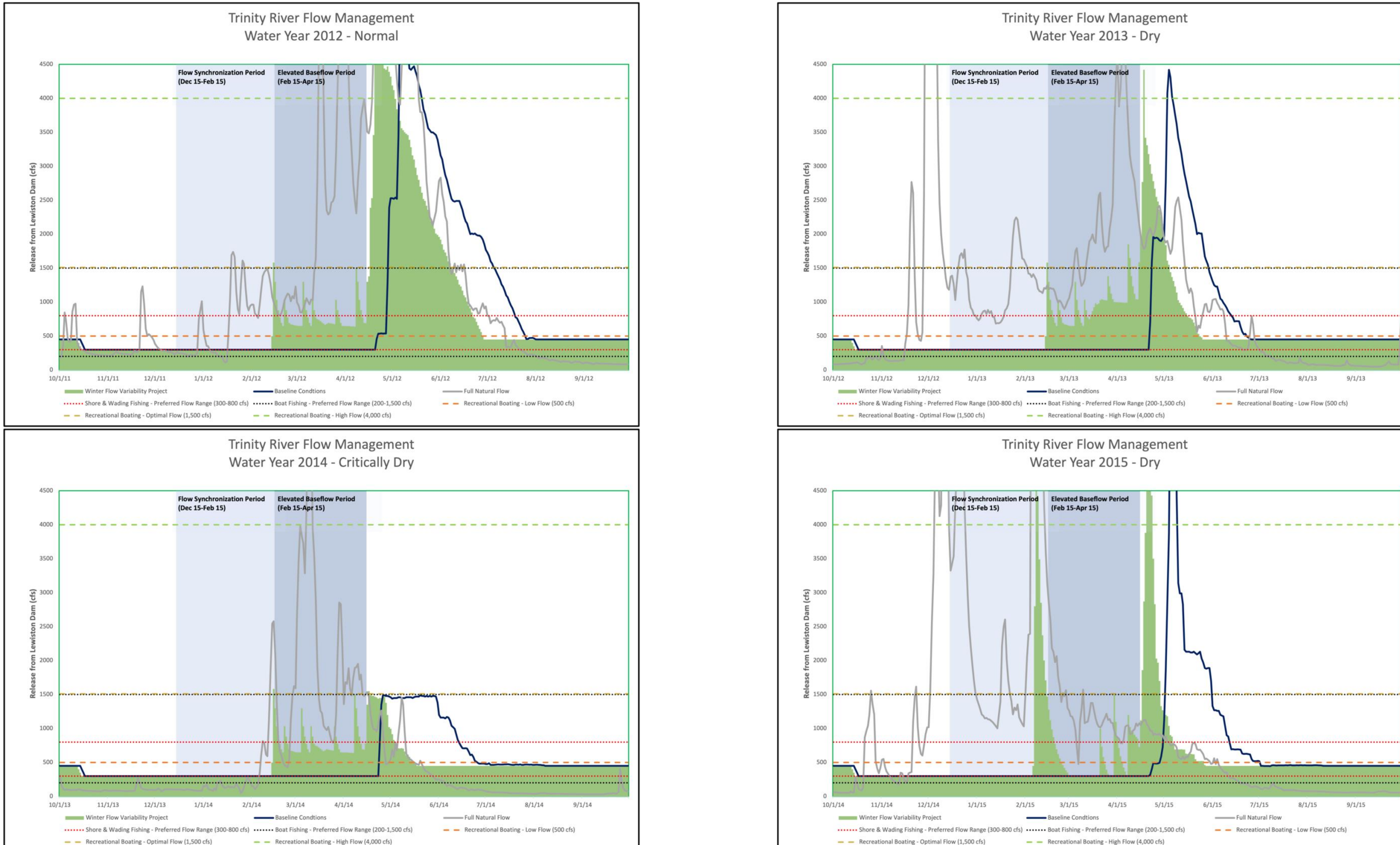


Figure 3-5. Trinity River hydrographs showing the baseline conditions, Winter Flow Project, and free flowing conditions for Water Years 2012 through 2015.

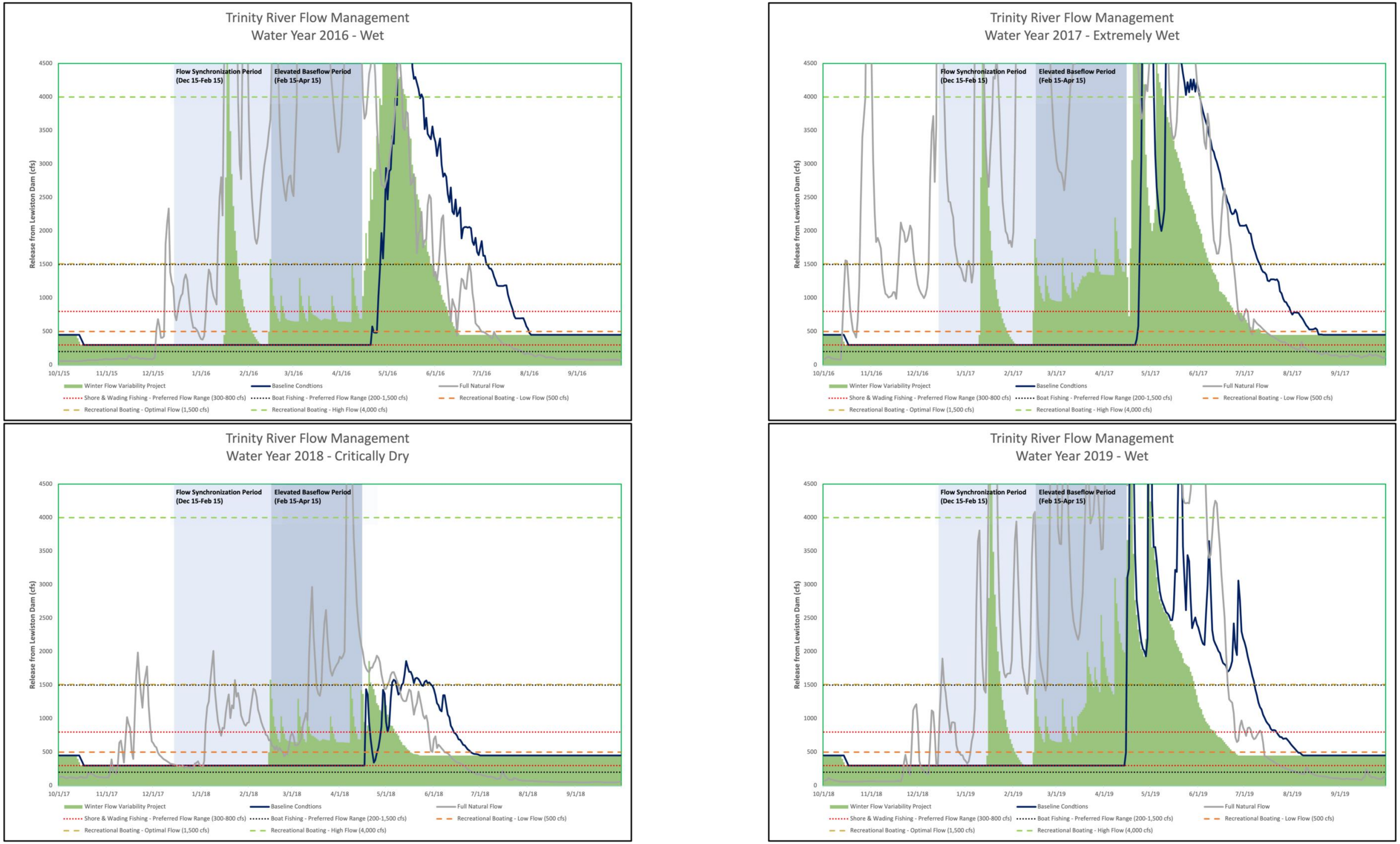


Figure 3-6. Trinity River hydrographs showing the baseline conditions, Winter Flow Project, and free flowing conditions for Water Years 2016 through 2019.

3.3.1 Flow Synchronization Period

The purpose of the flow action during this period would be to synchronize a high-magnitude dam release with a winter tributary high-flow event to mimic elevated flows that would have occurred in the mainstem Trinity River prior to dam construction.

Between December 15 and February 15 of each year, ROD water equivalent to 60,000 af would be released from Lewiston Dam when forecasting tools at the U.S. Geological Survey (USGS) mainstem gage above the North Fork indicate river levels of 4,500 to 12,000 cfs.[9] Reclamation set 6,500 cfs as the maximum average daily flow from Lewiston Dam during this period and determined that 60,000 af was the volume required for a one day peak of that allowed magnitude to occur when Trinity River FEIS ramping rates[10] for the ascending limb[11] and naturally observed ramping rates on the receding limb[12] were applied.

Following Reclamation's guidelines, the maximum flow released from Lewiston Dam during this period would not exceed 6,500 cfs average daily flow. Under current floodway infrastructure constraints, if the flow forecast exceeds 12,000 cfs at the USGS mainstem gage above the North Fork, the not-to-exceed 6,500 cfs synchronized flow release would not occur until the receding limb of the flow event is predicted to be 12,000 cfs or less at that gage. Synchronizing Lewiston Dam releases to the receding limb of natural tributary runoff events would be a conservative approach that avoids impacts on downstream properties and structures because there would no longer be uncertainty in the peak magnitude of the flow event. Flow magnitude thresholds for flow triggers and releases should be reevaluated as new information becomes available, or floodway infrastructure constraints change.

The peak flow during this period would be synchronized with storm events or "flow triggers," and would not occur if there were no storm events during this period that met the minimum 4,500 cfs forecast threshold. Analysis of post-ROD water years 2004 to 2019 shows that a flow trigger would have occurred between December 15 and February 15 in six of the 17 water years that were analyzed.

3.3.2 Elevated Baseflow Period

Between February 15 and April 15, ROD water would be released from Lewiston Dam based on DWR's 90% exceedance B120 water supply forecast,[13] which would prevent the overuse of ROD water should the

[9] Information for the current conditions at the North Fork gage, which is located above the junction of the mainstem and North Fork Trinity River, can be accessed at https://waterdata.usgs.gov/ca/nwis/uv?site_no=11526400.

[10] The ramping rate refers to the rate of change of water flow (in cubic feet per second per hour).

[11] The ascending limb of a hydrograph represents the rapid increase from rainfall that causes surface runoff and then later throughflow. Peak discharge occurs when the river reaches its highest level.

[12] The receding limb of a flow event is the point at which discharge into the river begins to decrease after peaking, and the river's levels fall.

[13] The 90% exceedance B120 water supply forecast indicates that there is a 90% chance that the water supply will exceed the forecast, and a 10% chance that it will fall short of the forecast.

water year end up being drier than expected. The predictive ability and methodological approach to using the 90% exceedance B120 water supply forecast is further described in Section 3.3.3.

Prior to the Elevated Baseflow Period, flow components that span the range of February and March forecast options would be developed by TRRP for approval by TMC. The elevated baseflow release schedule would be shared with interested parties on the TRRP website and through other customary avenues of public notification for flow actions, including but not limited to email listservs, fliers on public bulletin boards, mailers, and social media, shortly after its approval for release by Reclamation.

One key consideration in hydrographs in the historical record was the general trend of increasing baseflows throughout the early spring months leading into the peak snowmelt period. In considering the ecological functions of the river and the pre-Lewiston Dam record, it is important to capture this key hydrograph element in the Elevated Baseflow Period. Flow components developed for that period contain the trend of increasing spring baseflow that is present in the historical record, modest and appropriately spaced peaks to aid in ecological processes and salmonid food production, and flows that will provide increased channel margin habitat and floodplain inundation. The flows would be joined together with TRRP's spring flows that begin on April 15 to ensure a coherent and seamless flow release from Lewiston Dam each water year. To that end, it is important to note that any flow components implemented for the February release in the Elevated Baseflow Period would be scheduled through April 15 to ensure a no-release scenario in March of that same year would not result in a return to baseflow prior to the spring release. These recommended flow actions are expected to aid in overall river health, benefitting ecological processes that will help accomplish TRRP's goals.

The TRRP would rely on the Decision Tree shown in Note: The Decision Tree for the Winter Flow Project shows Flow Triggers releasing 60 thousand acre-feet (TAF) in Critically Dry years, 80 TAF in Dry years, 120 TAF in Normal years, 180 TAF in Wet years, and 220 TAF in Extremely Wet years prior to April 15.

Figure 3-2 to determine the volume of water to release during the Elevated Baseflow Period and the hydrograph component or components for that volume would be implemented. The Decision Tree process would occur when the DWR's February B120 forecast is posted, and again when the March B120 forecast is posted. DWR typically posts B120 forecasts about 8 to 10 days after the beginning of each calendar month.

The Decision Tree process would follow this outline:

1. Determine if a Flow Synchronization Period is implemented
    - Did a storm event (flow trigger) occur between December 15 and February 15 that resulted in a minimum discharge of 4,500 cfs at the USGS mainstem gage above the North Fork?
        - If yes, a Flow Synchronization of 60,000 af would be released regardless of water year type, so a maximum 6,500 cfs synchronization flow from Lewiston Dam would be timed to occur with tributary runoff.
        - If no, there would be no Flow Synchronization release implemented that year.
2. Determine Elevated Baseflow Period releases in February

- If the Flow Synchronization Period was implemented:
  - B120 forecast of Critically Dry or Dry would mean no February release.
  - B120 forecast of Normal would mean a 60,000 af release.
  - B120 forecast of Wet or Extremely Wet would mean a 120,000 af release.
- If no Flow Synchronization Period was implemented:
  - B120 forecast of Critically Dry or Dry would mean a 60,000 af release.
  - B120 forecast of Normal would mean a 120,000 af release
  - B120 forecast of Wet or Extremely Wet would mean a 180,000 af release.

3. Determine Elevated Baseflow Period releases in March

- If the Flow Synchronization Period was implemented:
  - B120 forecast of Critically Dry would mean no additional release would occur.
  - B120 forecast of Dry would mean a 20,000 af release.
  - B120 forecast of Normal could mean an additional 60,000 af release but would be based on whether the Normal winter period allocation of 120,000 af had yet to be met.
  - B120 forecast of Wet could mean an additional release if the Wet winter period allocation of 180,000 af had yet to be met.
  - B120 forecast of Extremely Wet water year forecast would mean an additional release of at least 40,000 af but could result in a higher release to reach the Extremely Wet winter period allocation of 220,000 af.
- If no Flow Synchronization Period was implemented:
  - B120 forecast of Critically Dry would mean no additional release.
  - B120 forecast of Dry would mean an additional 20,000 af release.
  - B120 forecast of Normal could result in an additional 60,000 af release if the Normal winter period allocation of 120,000 af had yet to be met.
  - B120 forecast of Wet could mean an additional release if the Wet winter period allocation of 180,000 af had yet to be met.
  - B120 forecast of Extremely Wet would mean an additional release of at least 40,000 af but could result in a higher release to reach the Extremely Wet winter period allocation of 220,000 af.

The Decision Tree guides the TRRP on the volume of ROD water available for release, but it can also be considered a balance sheet that ensures the volume shifted during the winter period will represent the March B120 90% exceedance forecast of the water year type and the volume prescribed in the winter period for that water year type each year (Table 3-2, third column). In other words, regardless of whether a flow trigger occurs and the Flow Synchronization Period release of 60,000 af is implemented, the overall volume of 60,000 af in Critically Dry, 80,000 af in Dry, 120,000 af in Normal, 180,000 af in Wet, and 220,000 af in Extremely Wet would be shifted to the winter period each year, according to the B120 90% exceedance forecast in March.

This flow management action has been designed to safeguard against the possibility that the actual water year determination (made in April each year) ends up being drier than predicted, as the overall volume of water to be shifted to the winter period (Table 3-2, fourth column) is considerably less than the ROD volume for that water year type.

Table 3-2. ROD water volumes and the percent shifted prior to April 15 under the Winter Flow Project for each water year type.

Water Year Type	ROD Water Volume (af)	ROD Volume Shifted to Winter Period under Winter Flow Project (af)	Percent ROD Volume Shifted to Winter Period
Critically Dry	369,000	60,000	16%
Dry	453,000	80,000	18%
Normal	647,000	120,000	19%
Wet	701,000	180,000	26%
Extremely Wet	815,000	220,000	27%

3.3.3 Methodological Approach for Initiating Releases Under Winter Flow Project

3.3.3.1 Precipitation Event Synchronization Forecasting

The TRRP would use the National Oceanic and Atmospheric Administration's (NOAA) California Nevada River Forecast Center (CNRFC) Hydrologic Ensemble Forecast Service (HEFS), which is deterministic up to 5 days prior to precipitation events.[14] The CNRFC has generated the HEFS for the Trinity River gage above the confluence of the North Fork Trinity River, at the location where all major tributaries that contribute to flood events in the TRRP restoration reach have entered the river.

Information from the CNRFC-HEFS would allow the TRRP to provide Reclamation a 72-hour notice to implement a winter flow synchronization event. The public would be notified at the same time through notices posted on the TRRP's winter flow variability page (located at: https://www.trrp.net/restoration/flows/winter-flow-variability/) and by emails to interested parties.

3.3.3.2 Using the B120 to Predict Water Year Type

Under the Winter Flow Project and as described above, winter baseflow increases based on predicted water year type would occur during the Elevated Baseflow period, between February 15 and April 15. Table 3-3 shows that since the implementation of ROD flows in 2004, the February and March 90% exceedance water supply forecast has never overpredicted the observed water year determination.

The Winter Flow Project moves some volume of these allocations prior to April 1, and B120 forecasts for February 1 and March 1 will be used to determine how much water will be moved in any given year.

[14] Information about the CNRFC-HEFS products can be accessed at https://www.cnrfc.noaa.gov/ensembleProduct.php?id=TRNC1&prodID=4.

Because the ultimate amount of water available for release to the Trinity River from Lewiston Dam in any given year depends on the April 1 B120 50% exceedance forecast, and forecasts in earlier months are not always the same as the April 1 forecast, it is necessary to understand how often earlier forecasts would inaccurately predict the amount of water that will ultimately become available.

Forecasted water volume inflows to Trinity Reservoir were available starting in water year 2004 and have been used to determine ROD water volumes each year since. The B120 50% and 90% exceedance forecasts for February, March, and April each year from 2004 to 2021 were used to evaluate the accuracy of February and March forecasts as compared to the April forecast, which determines ROD water volumes each year. For February and March forecasted volumes, the water year type and thus the ROD water volume were identified. These ROD volumes would be available for release from Lewiston Dam if the forecasted volume were equal to the April forecast.

Because annual ROD volumes are determined by the April forecast, the April prediction becomes the frame of reference when considering February and March forecasts in terms of whether these earlier forecasts overpredict or underpredict ROD allocations. Table 3-3 includes forecasted inflow volumes to Trinity Reservoir from B120 reports from 2004 to 2021; water year types that determine ROD water volumes; and indicators of how February and March forecasts compare to final water year determinations based on April forecasts. Indicators show how far February or March forecasts are from the final determination. For example, if a March forecast indicates a Dry water year but the ultimate determination is a Wet water year, "-2" indicates an under-forecast of two water year types. Likewise, if a Dry water year is forecasted in March and the final determination is a Dry water year, a "0" indicates that the March forecast was equal to the final determination.

The available record of February and March B120 90% exceedance forecasts in post-ROD years (2004 through 2021) has produced conservative predictions that track drier than the implemented water year type for each year (Table 3-3). Using the B120 90% exceedance water supply forecast to predict water volumes available for elevated base flows after February 15 is a conservative approach that would avoid "overspending" ROD volumes during the Flow Synchronization or Elevated Baseflow Periods because the forecast is a conservative water year prediction tool.

Table 3-3. The reliability of DWR's B120 since the beginning of ROD restoration releases in 2004. Median (50%) and 90% exceedance of forecasted inflow volumes to Trinity Reservoir (1000-acre feet), associated ROD water year type (WY Type), and accuracy of water year forecast relative to realized water year ROD allocation based on the median April forecast.

Year	February			March			April	
	90%	WY Type[1]	WY Accuracy[2]	90%	WY Type[1]	WY Accuracy[2]	Median (50%)	WY Type[1]
2004	1050	N	-1	1360	W	0	1580	W
2005	910	D	-1	920	D	-1	1245	N
2006	1278	N	-2	1531	W	-1	2105	EW
2007	550	CD	-1	795	D	0	835	D
2008	813	D	-1	880	D	-1	1065	N
2009	386	CD	-1	643	CD	-1	852	D
2010	386	CD	-2	1055	N	0	1310	N
2011	1040	N	-1	1125	N	-1	1800	W
2012	425	CD	-2	455	CD	-2	1025	N
2013	860	D	0	730	D	0	828	D
2014	145	CD	0	180	CD	0	395	CD
2015	600	CD	-1	830	D	0	934	D
2016	1030	N	-1	1085	N	-1	1600	W
2017	1515	W	-1	1770	W	-1	2265	EW
2018	500	CD	0	345	CD	0	530	CD
2019	810	D	-2	1060	N	-1	1595	W
2020	635	CD	0	500	CD	0	515	CD
2021	475	CD	0	380	CD	0	530	CD

[1] ROD water year type: CD = Critically Dry; D = Dry; N = Normal; W = Wet; EW = Extremely Wet

[2] Indicator of how far off WY type forecast is from the observed median April 1 B120 forecast. Under-forecasting is indicated as negative integers and over-forecasting as positive integers; e.g., under-forecasting of two water year types (dry vs. wet) is indicated by "-2."

3.4 Monitoring and Adaptive Management Approach

The 2000 ROD requires that the TRRP carry out its mandate through an adaptive management approach that utilizes the best available science to guide restoration activities. The TRRP is authorized to "recommend possible adjustments to the annual flow schedule within the designated flow volumes provided for in this ROD or other measures in order to ensure that the restoration and maintenance of the Trinity River anadromous fishery continues based on the best available scientific information and analysis."

Appendix C of the Trinity River FEIS, Implementation Plan, and AEAM Plan (USFWS et al. 2000b), states that the TRRP "will provide recommendations for the flow modifications for the OCAP [Operations Criteria and Plan] of the TRD of the CVP, if necessary." The ROD further states that "based on subsequent monitoring and studies guided by the TMC, the schedule for releasing water on a daily

basis, according to that year's hydrology, may be adjusted but the annual flow volumes outlined in the ROD may not be changed."

Appendix C of the Trinity River FEIS (USFWS et al. 2000b) states that AEAM will consist of a "designated team of scientists that recommend changes to fishery restoration efforts and annual operating schedules in response to monitored effects of implemented actions and in order to ensure that restoration goals of the Trinity River are effectively met. Alterations in magnitude and/or duration of releases into the Trinity River (while maintaining annual instream release volumes for each water year type) are dependent on the information/management needs of the TRRP. Any substantial deviation from the currently recommended fishery flow regime would be done in accordance with all applicable laws."

The Winter Flow Project is based on the concept of adaptive management and the ROD's requirement that TRRP implement an AEAM to guide future management of the Trinity River within the parameters established by the ROD. The implementation of the Winter Flow Project would likewise be guided by AEAM and a monitoring program to gauge the winter flow regime's effectiveness toward reaching the ROD's mandate of restoring the Trinity River's salmon fisheries to pre-dam levels.

The Winter Flow Project is expected to affect multiple ecosystem processes and components which are cumulatively expected to increase the growth rates of juvenile salmonids. Faster growth and more natural water temperatures are in turn expected to lead to earlier mean outmigration timing. This will give outmigrating salmonids a better chance of avoiding fatal diseases in the lower Klamath River such as *Ceratonova shasta*. Monitoring fish health and survival in the lower Klamath River and the ocean is outside of the scope of TRRP, but many pre-existing projects, notably the rotary screw traps that are annually operated on the Trinity River near its confluence with the North Fork Trinity River and in the lower river near Willow Creek, are well-situated to monitor the expected changes in fish growth and outmigration timing that will more directly be affected by winter flow variability.

3.4.1 Proposed Effectiveness Monitoring Based on Expected Outcomes

The following expected outcomes from implementation of the Winter Flow Project were initially described in the 2020 Trinity River Winter Flow Project EA. Proposed methods of effectiveness monitoring for each outcome are described below.

3.4.1.1 Channel Bed Mobilization

Expected Outcome: Enhance natural cleaning and transport of river gravels by overlapping tributary flows and Lewiston dam releases. Reduce buildup of sediment at tributary mouths, enhancing tributary and river confluence functions.

Channel bed mobilization is a process that can enhance bed porosity and fine sediment export rates to the benefit of organisms that inhabit bed interstices such as benthic macroinvertebrates and incubating salmonid eggs. In the current flow regime where minimal flows are released from Lewiston Dam during the winter, much of the Trinity River restoration reach is not expected to mobilize during the winter baseflow period because extreme weather events are required to create flows high enough to mobilize the channel bed. The Trinity River channel bed is expected to mobilize more frequently if mainstem flows are synchronized with tributary flows during the winter.

Channel bed mobilization can be monitored simply by accounting for the frequency that mainstem flows exceed the threshold needed to mobilize the channel bed at various locations on the Trinity River. It can also be monitored empirically using recently developed technology to detect the magnitude of bedload transport (Marineau et al. 2016). The bedload monitoring equipment can be deployed with as little as one day of notice at selected locations and used to show whether channel bed mobilization occurred.

3.4.1.2 Reduce Spring Cold-Water Releases

Expected Outcome: Reduce cold water releases in spring/summer so the growth of all native aquatic species (fish, their prey, and wildlife) will benefit. The negative impacts from cold water releases in the spring, including the suppression of salmonid metabolism and the indirect impacts of reduced growth rate of prey (macroinvertebrates) in the river, would be reduced.

This outcome can be evaluated in at least two ways using data from on-going and fully funded monitoring projects. The Fish Workgroup recently developed a temperature target for rearing juvenile salmonids specifically for the critical rearing period in spring/summer (7DADA of 13 – 16.5° C at the North Fork gauge from 1 April to 31 July). The hypothesis of reduced cold-water releases can be evaluated by comparing degree day exceedances of an implemented winter flow action to degree day exceedances of median observed temperatures from ROD flow releases of the same water year type as the implemented winter flow action. This would mean temperatures experienced by rearing juvenile salmonids spent more time within the optimal range. Second, reduced cold water suppression of growth and indirect impacts to prey can be evaluated by comparing mean size of outmigrants, total biomass of outmigrants, or biomass per spawner of outmigrants passing the Pear Tree and Willow Creek rotary screw traps to previous years under ROD flows. Size and biomass of outmigrants integrates the complex relationship between temperature and food availability, among other things, simultaneously providing a measure of temperature effects on fish metabolism and their prey. Notably, using fish data to evaluate this hypothesis would require several years of implementation due to the high natural variability of fish size and the numerous other factors that affect growth. Temperature can provide insight in a single year but is further removed from the Program's ultimate objectives and winter flow action to increase fish production.

3.4.1.3 Promote Seasonally Appropriate Outmigration

Expected Outcome: Allow the river to naturally warm earlier in the season to provide the proper environmental cues that smolts rely on to time their outmigration to the ocean.

This outcome can be evaluated using the median date of outmigration of juvenile salmonids at the Pear Tree and Willow Creek rotary screw traps. Changes to river temperatures can be quantified using existing temperature monitoring throughout the mainstem, and the degree day exceedance evaluation described above would also provide insight here. Specific desired timing of outmigration is yet to be identified by Program scientists, other than the recognition that fish should outmigrate earlier in drier years and later in wetter years, and that delaying outmigration by cold water releases can be detrimental when conditions in the lower Klamath River deteriorate prior to outmigration.

3.4.1.4 Increase Prey Through Inundation

Expected Outcome: Increase food availability for juvenile salmonids through earlier production of macroinvertebrate prey species. Increased winter and early spring flows would inundate shallow floodplains that support rooted plants and periphyton and promote macroinvertebrate and insect production earlier in the season, which would in turn be available for consumption by emerging fry.

This outcome can be evaluated in at least two ways, physical and biological. Increased floodplain inundation can be estimated using the Sediment and River Hydraulics two dimensional (SRH-2D) hydrodynamic model regularly used by the Program (Bradley 2018). The area of inundated floodplains within the 40-mile restoration reach can be estimated using SRH-2D and compared between an implemented winter flow action and a modeled hydrograph from the same year that would have been implemented in the absence of a winter flow action (i.e., a normal ROD release). The effects of floodplain inundation on macroinvertebrate and insect production can be evaluated by direct sampling on floodplains during inundation under an implemented winter flow action. A research project funded in FY2022 that will be implemented in FY2023 aims to conduct macroinvertebrate and periphyton sampling on inundated floodplains, comparing colonization and productivity to adjacent perennially wetted areas. While sampling methods are not identical to two recent research projects (Starkey-Owens 2020; Williamshen 2021) some useful comparisons can be made. Further work is needed to better understand the seasonal and longitudinal distribution of prey species in the restoration reach and their relationship to flow conditions.

3.4.1.5 Inundation of Rearing Habitat

Expected Outcome: Inundate naturally occurring and Program-created floodplains and other productive off-channel rearing habitats prior to fry emergence, provide access to relatively warm and productive floodplain nursery habitats after fry emergence and prior to downstream migration.

This outcome could be evaluated through modeling inundated areas using the hydraulic model, SRH-2D. Inundation extent of observed implemented winter variable flows would be compared to modeled inundation extent if dam releases were held at 300 cfs for the duration of the winter. Differences in inundation extent could be evaluated prior to fry emergence and from fry emergence to downstream migration. The timing of fry emergence can be estimated based on observed redd data and river temperatures from ongoing monitoring and temperature dependent development models available in literature. Timing of downstream migration can be estimated from rotary screw trap data. In addition, validation of a two-dimensional temperature module of the SRH-2D model is funded for FY2023. This module would provide estimates of local variation in water temperatures, e.g., on a floodplain separately from the adjacent mainstem river, which would allow higher resolution temperature analyses of floodplain and other off-channel habitats.

3.4.1.6 Additional Monitoring

Monitoring projects not described above that may guide future activities under the AEAM concept include:

- Water temperature monitoring-temperature compliance

- Flow magnitude and stage height-inundation and recession, riparian recruitment, and riparian scour
- Geomorphic monitoring – delta monitoring (aerial photo), planform change (bathymetry and lidar 5-yr), sediment transport, and bed substrate composition
- Benthic Macroinvertebrate studies
- Fish feeding rate (Net Rate Energy Intake modeling) studies
- Several projects designed to estimate the number of adult salmon that are either harvested or survive to spawn in the Trinity River
- If implemented, Program scientists will observe the Trinity River and its fishery and propose additional hypotheses.

4. Analysis of the Potential Effects on Salmon Fisheries

This section provides an in-depth description of the methods used and the results of resource analyses completed for the Winter Flow Project, to address the cascading effects to salmon populations that are described in Section 2. The affected environment along the 40-mile Trinity River restoration reach, between Lewiston Dam and the confluence of the North Fork Trinity River and those that would extend through and beyond the restoration reach, are analyzed. This section is primarily focused on salmon, for which benefits are targeted from the scientific rationale for the Winter Flow Project, as discussed in Section 2. Effects on other resources and the ecological form and function of the Trinity River are addressed in Section 5.

As discussed in Section 2.2 , temperatures in the Trinity River are suppressed during late spring and summer months by restoration releases, impacting the quality of water for fisheries and salmonid growth. Analysis indicates that restoration releases under the Winter Flow Project would result in warmer Trinity River temperatures earlier in the year.

4.1 Temperature Targets and Thresholds

4.1.1 Methods

Compliance with adult holding and outmigration temperature targets have been evaluated annually by calculating the degree day exceedances of the targets (Table 4-1). Positive differences between daily average temperatures and a given target are summed over the period defined by the target to produce an estimate for each target in each year. Compliance with the rearing target is evaluated in the same way for the upper threshold of 16.5°C; the lower threshold is evaluated in a comparable manner by summing daily deviations below the minimum temperature range of 13°C. In addition, the rearing target is evaluated using the 7-day moving average of the daily average (7DADA) rather than the observed daily average temperatures.

To evaluate the effects of the Winter Flow Project on compliance with temperature objectives, daily average temperatures estimated from RBM10 from 2004 to 2019 were used for the hypothetical hydrographs (Figure 3-3 through Figure 3-6) that represent baseline conditions and the Winter Flow Project. Exceedances were calculated separately for each temperature target for each year for the hypothetical scenarios.

4.1.2 Adult Holding Temperature Targets

Under baseline conditions, adult holding targets are met in most years and exceedances are small when they occur (Table 4-1 and Figure 4-1). Larger exceedances of the July 1 to September 14 15.6°C target at Douglas City were estimated to have occurred under the Winter Flow Project scenario in a few years but were of a similar magnitude to observed exceedances under current flow management. The largest differences occurred in 2005 and 2010, when degree-day exceedances for the Winter Flow Project were 6.5-degree days in both years at Douglas City. In 2005, the largest 1-day exceedance was 1.2°C (modeled temperature of 18.8°C) and exceedances were more than 1°C for only 5 days. In 2010, the largest 1-day exceedance was 0.6°C. Temperatures in this range do not pose a threat to holding spring Chinook Salmon

and only occur for a short time, thus the Winter Flow Project is not expected to have a significant impact on adult salmonids. Observed and estimated exceedances for the two later targets are identical because flows are always returned to baseflow prior to September 15, so temperatures are the same between the Winter Flow Project and the baseline conditions.

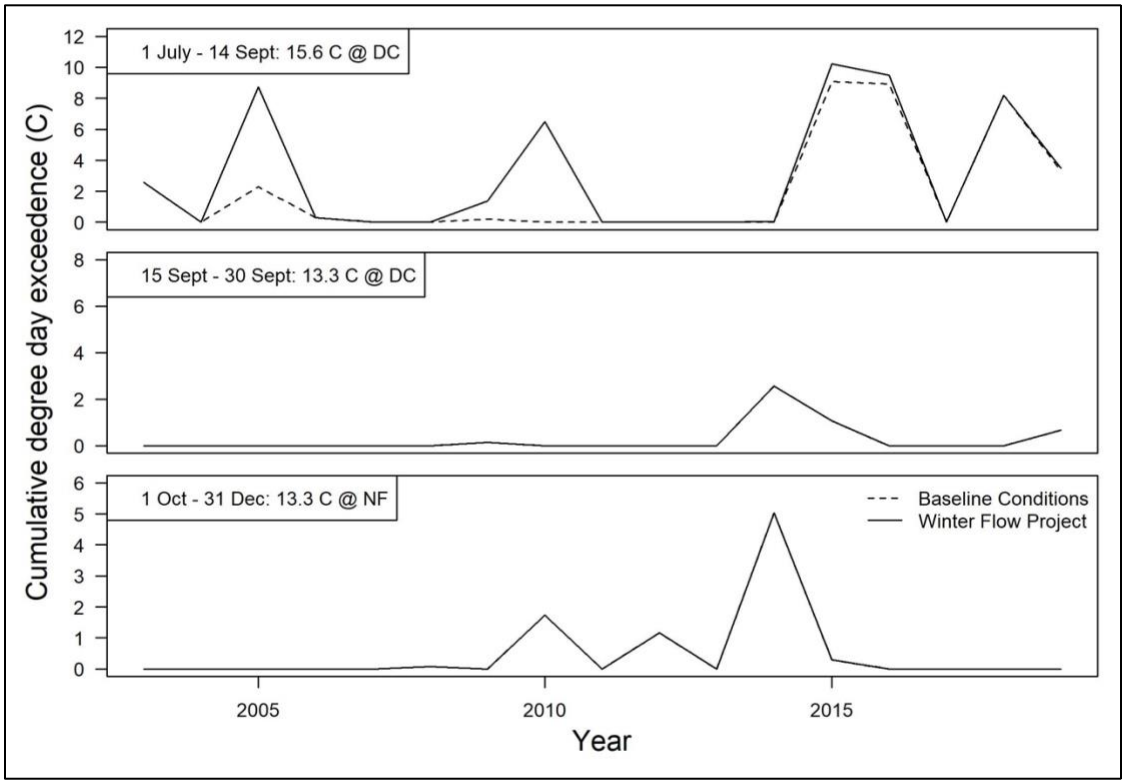


Figure 4-1. Timeseries of degree day exceedances of adult spring Chinook Salmon holding temperature targets for the Trinity River at Douglas City and the North Fork Trinity River for hypothetical hydrographs consistent with baseline conditions and the Winter Flow Project.

Table 4-1. Annual degree day exceedances of adult spring Chinook Salmon holding temperature targets from 2004 to 2019 based on RBM10 temperature modeling of the mainstem Trinity River under hypothetical hydrographs consistent with baseline conditions and the Winter Flow Project.

Year	Baseline Conditions			Winter Flow Project		
	Douglas City July 1 - Sept 14	Douglas City Sept 15 - Sept 30	North Fork Oct 1 - Dec 31	Douglas City July 1 - Sept 14	Douglas City Sept 15 – Sept 30	North Fork Oct 1 - Dec 31
2003	2.57	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00
2005	2.28	0.00	0.00	8.73	0.00	0.00
2006	0.29	0.00	0.00	0.29	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.07	0.00	0.00	0.07
2009	0.19	0.13	0.00	1.38	0.13	0.00
2010	0.00	0.00	1.73	6.50	0.00	1.73
2011	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	1.17	0.00	0.00	1.17
2013	0.00	0.00	0.00	0.00	0.00	0.00
2014	0.00	2.57	5.03	0.04	2.57	5.03
2015	9.08	1.07	0.30	10.22	1.07	0.30
2016	8.91	0.00	0.00	9.49	0.00	0.00
2017	0.00	0.00	0.00	0.00	0.00	0.00
2018	8.20	0.00	0.00	8.20	0.00	0.00
2019	3.29	0.67	0.00	3.49	0.67	0.00

4.1.3 Outmigration Temperature Targets

As mentioned previously, the outmigration temperature targets at Weitchpec are under review by the TRRP and are generally considered to result in the upper river being too cold. Details can be found in Fish Workgroup meeting notes and documents supporting the development of the juvenile rearing targets[15]. The targets were established with the premise that maintaining suitably cold temperatures would encourage juvenile salmonids to rear longer and thus grow larger before outmigrating from the Trinity River. However, this did not consider that the entire river upstream of Weitchpec would need to be much colder to result in low temperatures at Weitchpec, suboptimal cold temperatures suppress growth, and later emigration from the Trinity River potentially puts fish at risk in the lower Klamath River as conditions there become unsuitable for outmigrating smolts earlier in the year compared to the Trinity River.

[15] Information and complete meeting notes and agendas for the TRRP Fish Workgroup can be found at https://www.trrp.net/calendar/fish-workgroup/.

Degree day exceedances are presented here because these targets have longstanding in the Program. The outmigration targets are exceeded almost every year under current flow management and are exceeded more under the Winter Flow Project (Table 4-2 and Figure 4-2). However, warming the Trinity River earlier in the year to encourage earlier emigration is a stated objective of the Winter Flow Project, so increased exceedances under the Winter Flow Project are expected.

4.1.4 Juvenile Rearing Temperature Targets

Warmer temperatures in spring and early summer also affect the Program's ability to achieve juvenile rearing temperature targets. Negative deviations are less under the Winter Flow Project, meaning the river is warmer and spends less time in the suboptimal cold temperature range (Table 4-3, Figure 4-3). Positive deviations are greater under the Winter Flow Project, which is an expected result of returning to summer baseflow earlier. Closer examination of the temperature time series indicates that exceedances are almost entirely attributed to temperatures in July and rarely exceed 20°C. Nearly all juvenile Chinook Salmon have emigrated out of the restoration reach by July and maximum temperatures that would have the most detrimental effect on juvenile salmonids that are present year-round occur later in the year when there is no difference between the Winter Flow Project and current flow management. Consequently, the increased positive deviations from the juvenile rearing temperature target are not expected to have a substantive negative impact on rearing juvenile salmonids as compared to current flow management.

In summary, the adult-holding and juvenile-rearing temperature targets are exceeded slightly more under the Winter Flow Project when compared to the baseline conditions. The 450 cfs summer-base flow maintained in the Winter Flow Project, under most environmental conditions, is adequate to maintain the temperature targets for adult holding at Douglas City. This summer minimum 450 cfs baseflow is the same under both baseline conditions and the Winter Flow Project.

By shifting a portion of ROD water to the winter period, the Winter Flow Project would allow nursery areas to wet and begin warming earlier in the season and decrease temperature suppression from cold water dam releases by scaling down the amount of water released during the critical growth period, thus allowing river temperatures to elevate into the Fish Workgroup's proposed target range for juvenile rearing. This would improve conditions for fish growth and is discussed below. In other words, the precipitous drop in temperature that occurs with restoration releases at the end of April would be reduced, promoting juvenile fish growth.

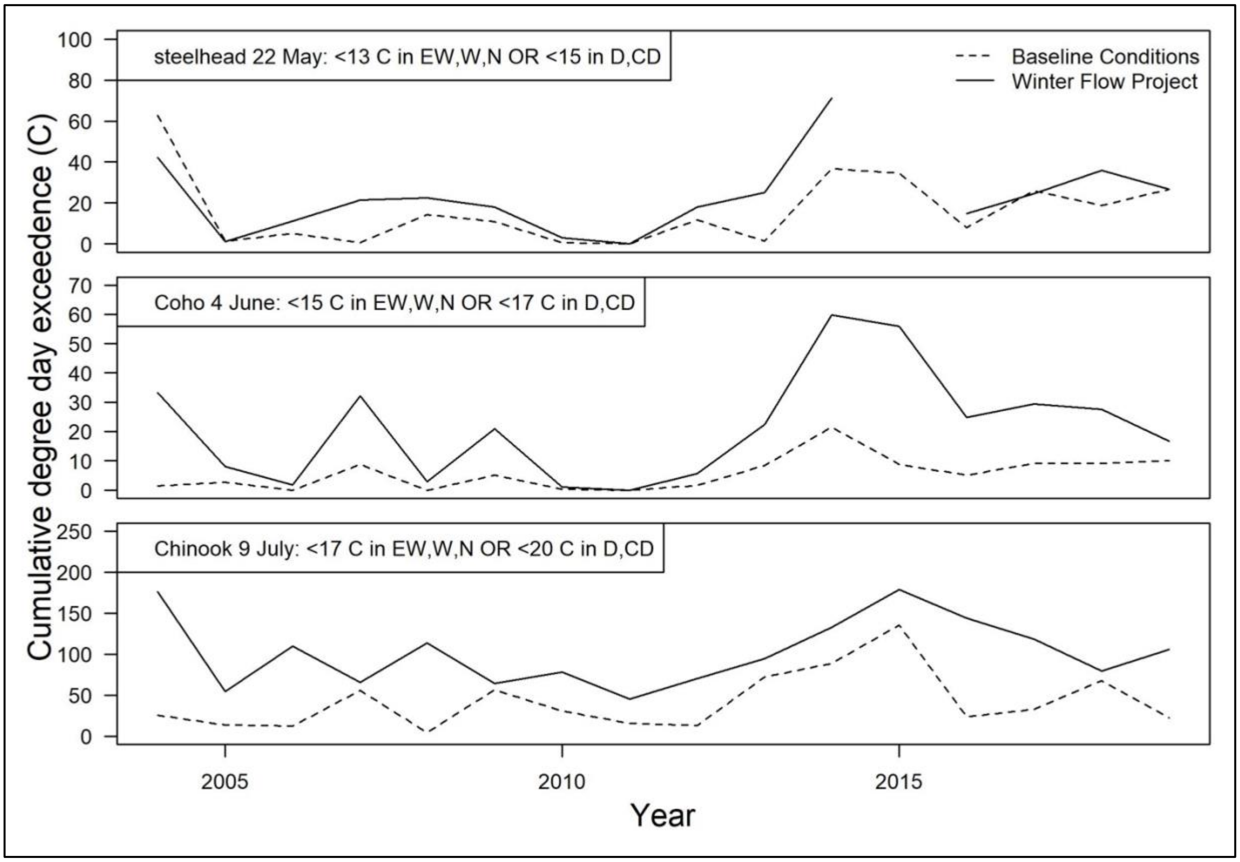


Figure 4-2. Timeseries of degree-day exceedances of juvenile salmonid outmigration temperature targets for the Trinity River at Weitchpec for hypothetical hydrographs consistent with baseline conditions and the Winter Flow Project.

Table 4-2. Annual degree-day exceedances of juvenile outmigration temperature targets from 2004 to 2019 based on RBM10 temperature modeling of the mainstem Trinity River under hypothetical hydrographs consistent with baseline conditions and the Winter Flow Project.

Year	WY Type	Baseline Conditions			Winter Flow Project		
		Steelhead May 22	Coho June 4	Chinook July 9	Steelhead May 22	Coho June 4	Chinook July 9
2004	Wet	62.7	1.3	25.1	42.2	33.3	176.0
2005	Normal	1.3	2.7	13.8	1.2	8.0	54.5
2006	Extremely Wet	5.0	0.0	12.4	11.2	1.8	109.9
2007	Dry	0.7	8.7	55.8	21.4	32.2	65.3
2008	Normal	14.4	0.0	4.3	22.5	2.9	113.7
2009	Dry	11.0	5.1	56.3	18.0	21.0	64.1
2010	Normal	0.7	0.2	30.9	2.9	1.0	77.9
2011	Wet	0.0	0.0	15.6	0.0	0.0	45.2
2012	Normal	11.8	1.6	13.2	18.1	5.7	70.2
2013	Dry	1.3	8.3	71.9	25.1	22.4	94.4
2014	Critically Dry	36.7	21.5	88.7	71.1	59.9	132.5
2015	Dry	34.5	8.8	135.4	52.4	56.0	179.1
2016	Wet	8.0	5.0	23.3	14.9	24.8	144.2
2017	Extremely Wet	25.9	9.1	32.7	24.5	29.4	117.9
2018	Critically Dry	18.7	9.2	67.5	36.0	27.5	79.7
2019	Wet	26.8	10.0	22.3	26.8	16.6	105.5

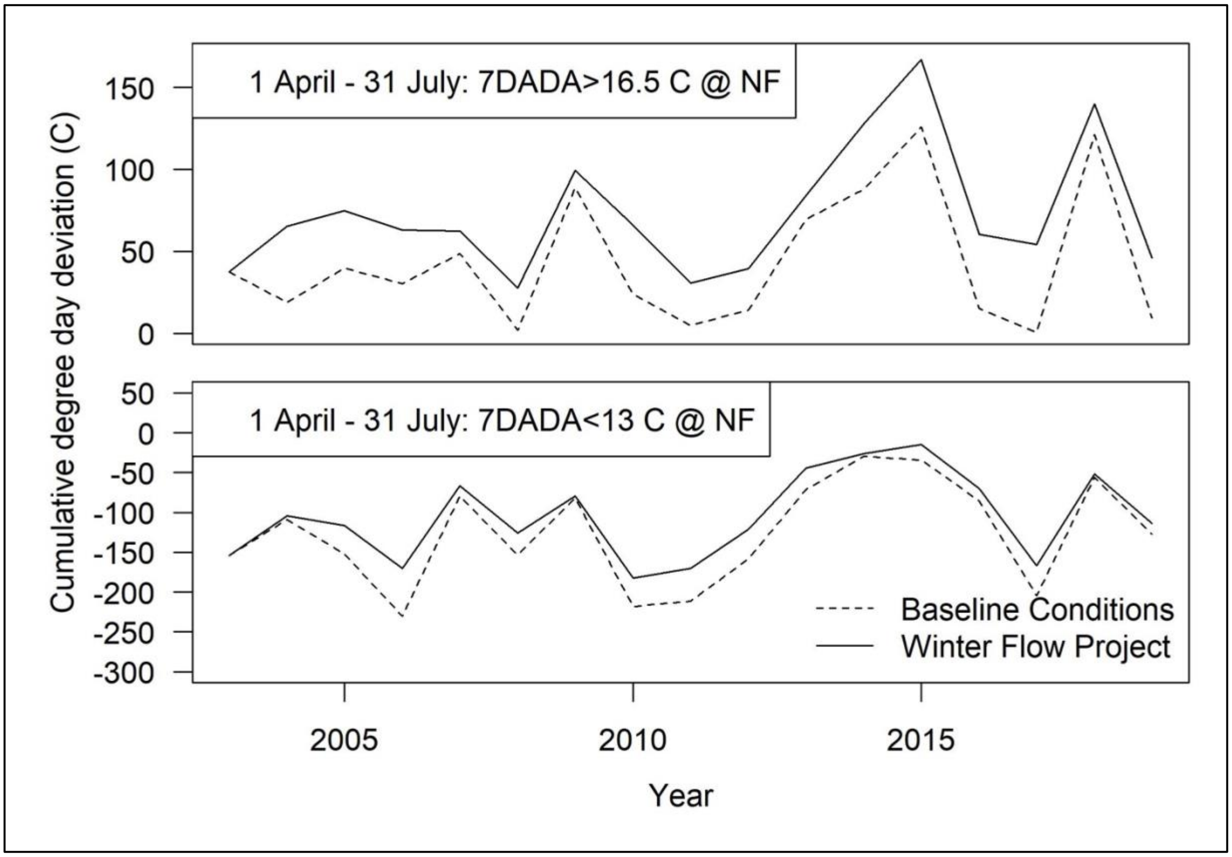


Figure 4-3. Timeseries of degree-day deviations of juvenile rearing temperature targets for the Trinity River at the North Fork Trinity River for hypothetical hydrographs consistent with the baseline conditions and the Winter Flow Project.

Table 4-3. Annual degree day deviations of juvenile rearing temperature targets from 2004 to 2019 based on RBM10 temperature modeling of the mainstem Trinity River under hypothetical hydrographs consistent with the baseline conditions and Winter Flow Project.

Year	Baseline Conditions		Winter Flow Project	
	Negative Deviations	Positive Deviations	Negative Deviations	Positive Deviations
2003	-154.14	37.50	0.00	0.00
2004	-108.74	18.96	-104.49	65.31
2005	-152.24	39.77	-116.51	74.91
2006	-230.06	30.33	-170.06	63.04
2007	-79.14	48.61	-66.51	62.20
2008	-153.33	1.84	-125.77	27.69
2009	-82.37	88.94	-79.57	99.47
2010	-218.20	23.89	-182.76	65.81
2011	-211.14	4.63	-170.17	30.51
2012	-158.56	14.26	-121.36	39.31
2013	-71.63	69.54	-44.39	84.09
2014	-29.70	87.97	-26.50	127.77
2015	-34.24	125.86	-14.90	167.01
2016	-85.57	15.17	-69.73	60.36
2017	-204.51	0.67	-166.96	54.14
2018	-55.57	121.09	-51.90	139.93
2019	-127.20	9.37	-113.90	45.94

4.2 Salmonid Growth, Biomass and Abundance

4.2.1 Methods

Thermal effects of Winter Flow Project and baseline conditions were evaluated using the RBM10 model predictions at Lewiston, Pear Tree upstream of the North Fork (NF) Trinity River, and Hoopa. The RBM10 model simulates daily average river temperatures downstream from Lewiston Dam to the confluence of the Klamath and Trinity Rivers, and from Iron Gate Dam on the Klamath River downstream to the mouth of the Klamath River (Perry et al. 2011; Jones et al. 2016). The model uses a simple equilibrium flow model, instantly transmitting river flow downstream through each river segment each day. It also uses a heat budget to calculate flux across the air-water interface, using inputs derived from gridded meteorological datasets. Model boundary conditions include flow and temperature for the Trinity River at Lewiston Dam and 14 tributaries to the Trinity River (Jones et al. 2016).

Growth of juvenile Chinook Salmon was evaluated using two different methods. To obtain the daily mass (g) of juvenile Chinook Salmon, the Ratkowski growth model parameterized by Perry et al. (2015) was used. Growth rates of juvenile Chinook Salmon produced by the Ratkowski model are similar to growth rates produced at two-thirds of maximum consumption in the Wisconsin bioenergetics model (Perry et al. 2018). For each year, initial mass at emergence from gravel for Chinook Salmon fry was set to 0.3 g on

February 1. Thereafter, water temperatures from the RBM10 model results were fed into the Ratkowski growth model, resulting in daily weight (grams [g]) of Chinook Salmon at each of the three locations: Lewiston, Pear Tree upstream of the NF Trinity River, and Hoopa.

To obtain the daily growth rate (g/g/d), the Wisconsin Bioenergetics model (Stewart and Ibarra 1991; Plumb and Moffitt 2015) was used, with parameterization of the model following methods outlined in Perry et al. (2018). Mass of juvenile Chinook Salmon was set to 3 g, with the proportion of maximum consumption assumed to equal 0.66. The RBM10 model results were fed into the Wisconsin Bioenergetics model, resulting in g/g/d of juvenile Chinook Salmon at each of the three locations: Lewiston, Pear Tree upstream of the NF Trinity River, and Hoopa.

Additionally, the difference in biomass and abundance of juvenile Chinook Salmon were evaluated using the Stream Salmonid Simulator (S3) developed by Perry et al. (2018), which requires water temperature and streamflow as physical inputs. The model was applied using existing data over 14 years (2006-2019) under baseline conditions and modeled data under the Winter Flow Project, and the differences in biomass and abundance under the two scenarios were calculated for Pear Tree and Weitchpec.

4.2.2 Effects of Temperature on Growth and Metabolism

The modeled water temperatures and their effect on modeled Chinook Salmon mass (g) showed that in all years (2004-2019), Winter Flow Project results in greater end-of-June mass than baseline conditions (Figure 4-4 and Table 4-4). Differences in the end-of-June mass for the Winter Flow Project and baseline conditions ranged from 1.1g to 2.2g. The resulting differences in mass as a percentage of end-of-June Chinook Salmon size ranged from 5.7% to 19.2% over the study period. The relationship between total Lewiston Dam restoration release water year volume and the percentage difference in end-of-June mass between the baseline conditions and the Winter Flow Project was significant ($R^2 = 0.584$; $P < 0.001$), resulting from the warmer water temperatures that Winter Flow Project provides in the spring months relative to that of the baseline conditions. The effect is most pronounced in wetter water year types, as the Winter Flow Project moves a larger volume of water from the spring juvenile Chinook Salmon rearing period to the winter months.

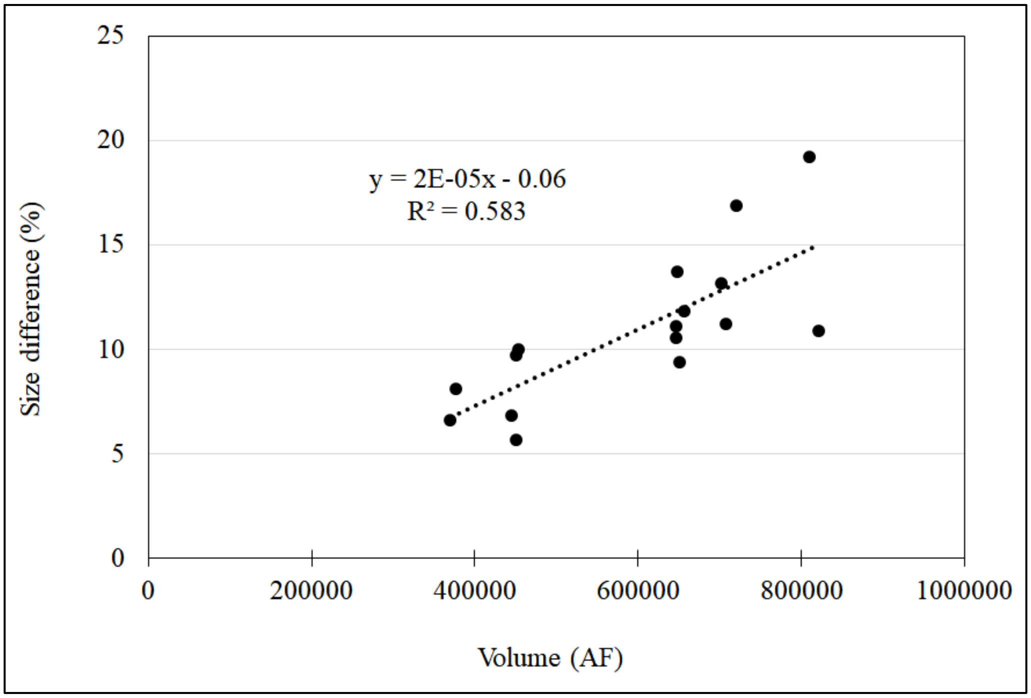


Figure 4-4. Relationship between end-of-June size difference (%) between the Winter Flow Project and baseline conditions (BC; *Winter Flow Project - BC*), and annual Lewiston Dam restoration release water volumes for water years 2004 to 2019 (R2 = 0.583; P < 0.001).

Table 4-4. End-of-June mass (g), and difference between the Winter Flow Project and the baseline conditions. Water volumes are annual Lewiston Dam restoration release water volumes for water years 2004 to 2019.

Year	Forecast	Volume (af)	Mass-Action (g)	Mass-Baseline Conditions (g)	Difference (g)	Difference (%)
2004	Wet	651,000	15.7	14.2	1.5	9.4
2005	Normal	647,600	14.7	13.1	1.6	11.1
2006	Ext Wet	809,900	11.3	9.1	2.2	19.2
2007	Dry	453,700	17.2	15.5	1.7	10.0
2008	Normal	648,700	13.5	11.6	1.8	13.7
2009	Dry	445,500	15.9	14.8	1.1	6.8
2010	Normal	656,700	12.6	11.1	1.5	11.8
2011	Wet	721,800	11.7	9.7	2.0	16.8
2012	Normal	647,100	12.5	11.2	1.3	10.5
2013	Dry	451,900	17.3	15.6	1.7	9.7
2014	Crit Dry	370,500	20.9	19.5	1.4	6.6
2015	Dry	450,700	23.6	22.2	1.3	5.7
2016	Wet	708,800	16.4	14.6	1.8	11.2
2017	Ext Wet	821,266	12.3	11.0	1.3	10.8
2018	Crit Dry	377,072	17.7	16.3	1.4	8.1
2019	Wet	703,093	13.6	11.8	1.8	13.1

Figures and results for the Pear Tree upstream of the NF Trinity River are presented below to facilitate comparison of the baseline conditions and Winter Flow Project for each of the five water year types. Additionally, this is the downstream extent of channel restoration work conducted by the TRRP. The g/g/d was generally higher for Winter Flow Project than under baseline conditions throughout the February to June period, with the largest differences in growth rate between the baseline conditions and the Winter Flow Project in June of wetter years (Figure 4-5). [16]

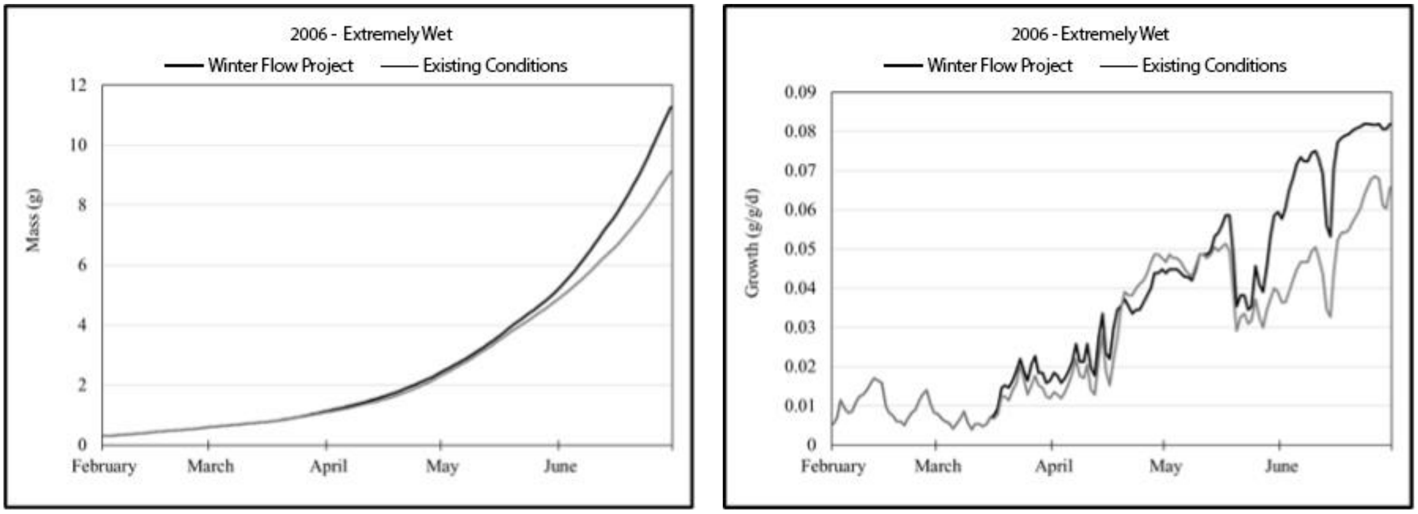
This occurs because Winter Flow Project results in shifting a larger volume of water from the spring to the winter months in wetter years when, under current flow management, temperature suppression is most pronounced, thereby resulting in better (warmer) growth temperatures for Chinook Salmon. The differences in daily growth rates of juvenile Chinook Salmon between baseline conditions and the Winter Flow Project are less in dryer water years than in wetter water years, where the water temperatures

[16] Differences in the end-of-June mass for the Winter Flow Project and the baseline conditions alternative ranged from 1.1 grams (g) to 2.2 g. The resulting differences in mass as a percentage of end-of-June Chinook Salmon size ranged from 5.7 percent to 19.2 percent over the study period. The relationship between total water year volume and the percentage difference in end-of-June mass between the baseline conditions and the Winter Flow Project was significant ($R^2 = 0.594$; $P < 0.001$), resulting from the warmer water temperatures that the alternative provides in the spring months relative to that of the baseline conditions.

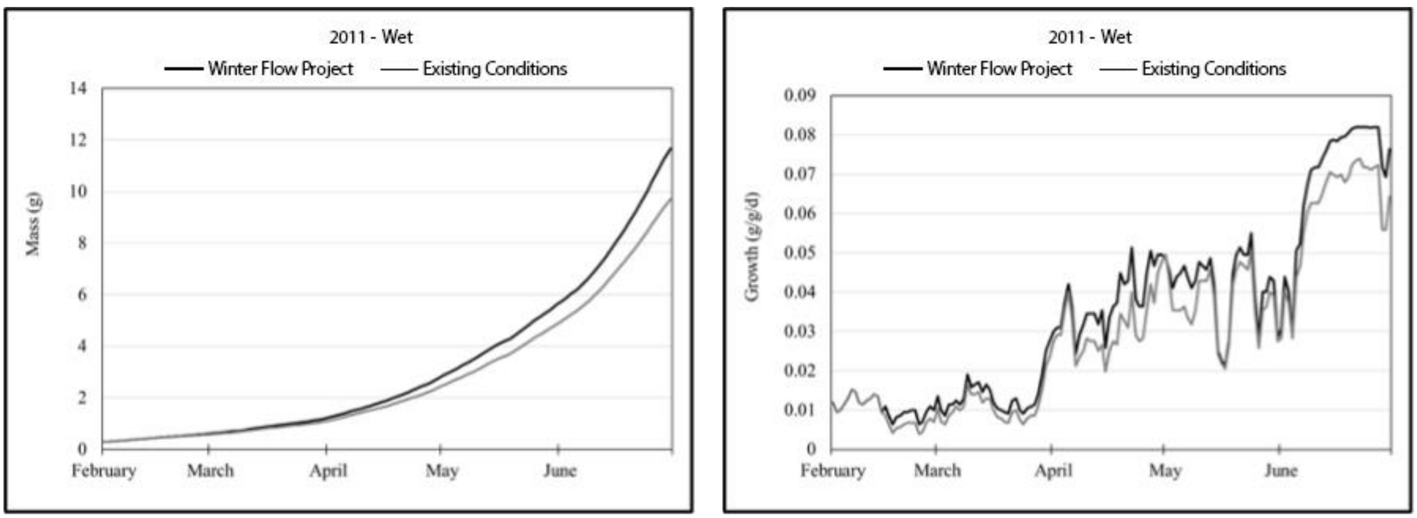
provided by the baseline conditions and the Winter Flow Project are more similar to each other. These findings comport very well with those of Thomas Gast & Associates (2019), which found a statistically significant positive relationship between water temperature (accumulated thermal units) and the date that both 80% and 50% of Chinook Salmon had outmigrated past the Pear Tree rotary screw trap. In years with warmer water temperatures, Chinook Salmon outmigrated earlier in the year (Thomas Gast & Associates 2019). This likely occurs because they grow at a higher rate in warmer water temperatures (Thomas Gast & Associates 2019), provided temperatures are not so warm that the metabolic costs inhibit growth.

4.2.3 Modeled Biomass and Abundance Using S3

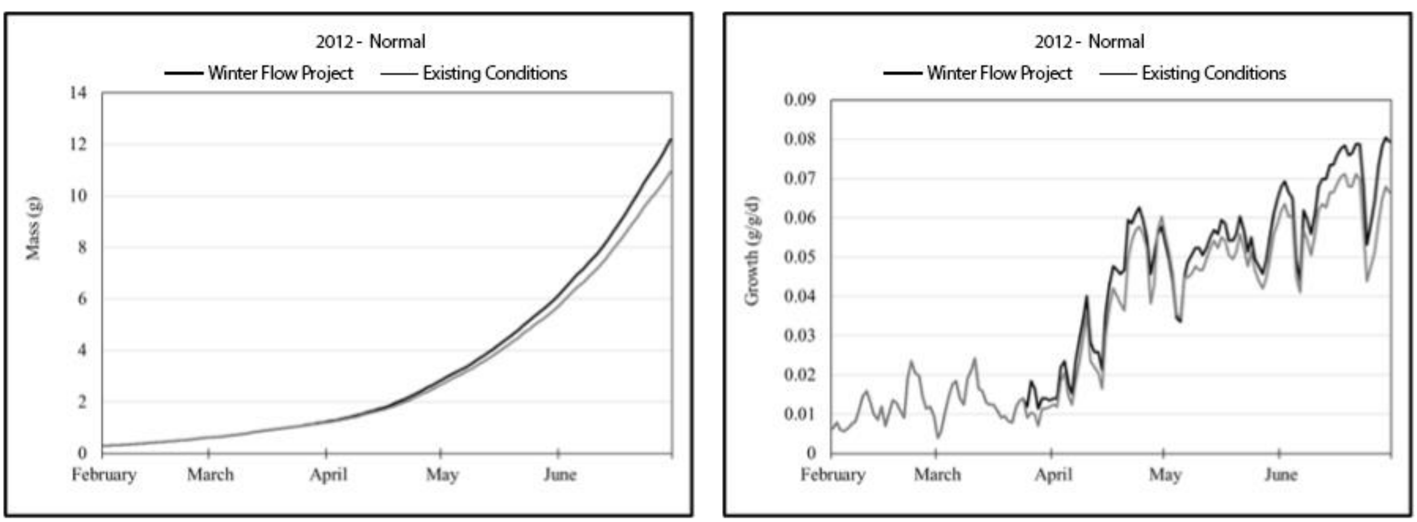
Results of S3 simulations under the Winter Flow Project (Table 4-5) show that in most years, implementation of the Project would have resulted in an increase in biomass at Pear Tree upstream of the North Fork and Weitchpec in the mainstem. While the S3 model does not predict greater abundance overall under the Project, it predicts a positive effect on biomass in 9 of the 14 years, a net increase in biomass over the 14-year period, and an increased abundance at the larger life stages of parr and smolt over the 14-year period. The overall increase in parr and smolt abundance is expected to occur because fish grow larger in the model using the Project scenario, therefore maturing into larger life stages more rapidly. This is a desired effect because larger individuals are expected to have higher survival (Pearcy 1992; Beamish and Mahnken 2001).



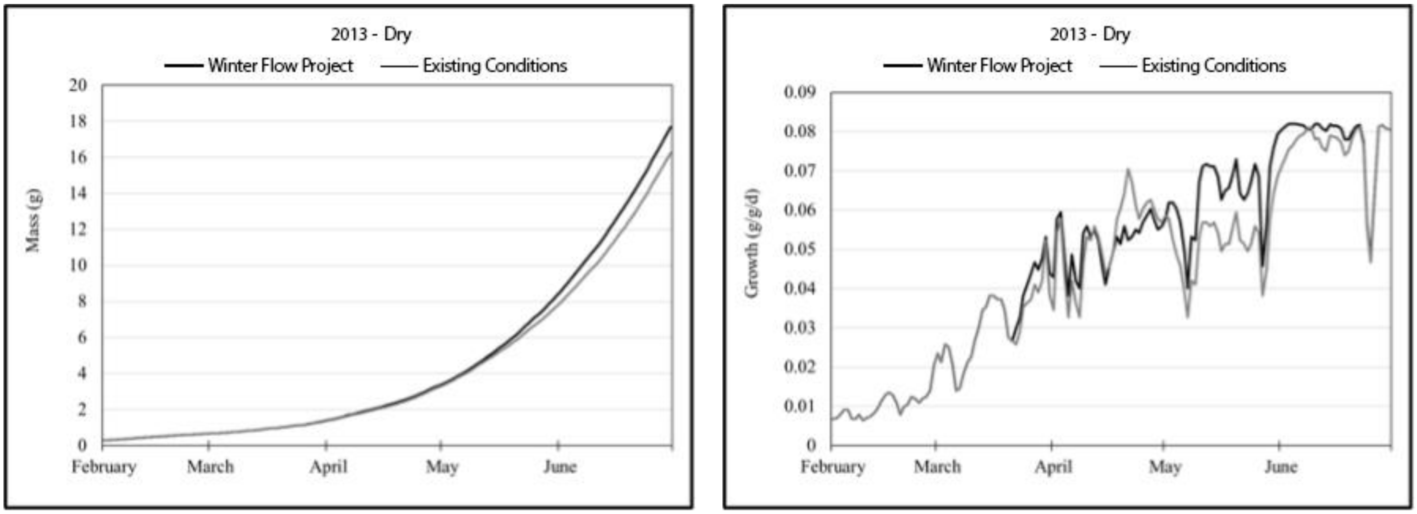
2006 – Extremely Wet



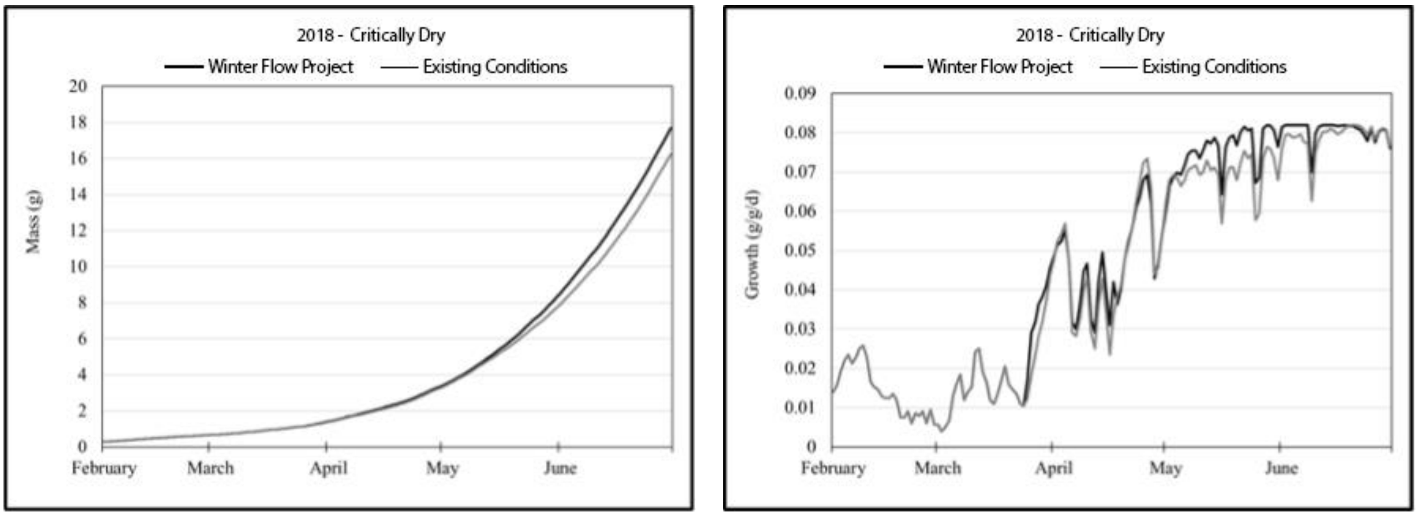
2011 – Wet



2012 – Normal



2013 – Dry



2018 – Critically Dry

Figure 4-5. Difference in end-of-June mass (g) and growth (g/g/d) between the Winter Flow Project and the baseline conditions BC; Winter Flow Project - BC) at Pear Tree upstream of the NF Trinity River.

Table 4-5. Difference in biomass (%) and abundance (%) between the Winter Flow Project and baseline conditions at Pear Tree upstream of the NF Trinity River and Weitchpec in the mainstem.

Year	Water Year Type	Fry Abundance	Parr Abundance	Smolt Abundance	Total Abundance	Total Biomass	Fry Abundance	Parr Abundance	Smolt Abundance	Total Abundanc e	Total Biomass
		Pear Tree					Weitchpec				
2006	Ext Wet	-9.1%	7.5%	0	-0.5%	8.8%	9.3%	-1.0%	6.2%	-89.8%	1.8%
2007	Dry	2.0%	2.3%	0	2.2%	6.9%	4.6%	4.1%	-1.5%	226.3%	1.1%
2008	Dry	-1.8%	1.2%	0	0.0%	5.0%	4.9%	-5.8%	6.5%	-66.9%	-0.3%
2009	Dry	0.7%	-0.9%	0	-0.1%	-0.8%	-0.7%	5.4%	-2.0%	317.2%	1.2%
2010	Wet	-6.6%	8.5%	0	-2.5%	2.8%	5.4%	-1.0%	2.0%	-52.8%	0.1%
2011	Wet	-9.0%	13.6%	0	-1.9%	5.2%	7.2%	-10.9%	14.4%	-21.1%	-2.7%
2012	Normal	-6.1%	9.0%	0	-0.6%	4.3%	5.0%	-4.2%	4.4%	-93.4%	-0.1%
2013	Dry	-2.7%	2.0%	0	-0.7%	3.1%	3.8%	2.5%	0.4%	1105.1%	1.4%
2014	Crit Dry	-1.4%	0.9%	0	-0.7%	-1.2%	-0.5%	-5.1%	-0.6%	-51.1%	-2.7%
2015	Dry	1.8%	-2.1%	0	0.3%	-0.2%	-0.5%	-2.2%	0.5%	124.7%	-0.6%
2016	Wet	-0.4%	-1.3%	0	-0.6%	-1.3%	-0.7%	19.2%	-10.4%	-95.0%	0.2%
2017	Ext Wet	0.8%	5.7%	0	1.5%	-0.2%	-1.7%	0.1%	0.0%	-97.2%	0.1%
2018	Crit Dry	-4.2%	5.5%	0	-1.4%	1.6%	3.1%	-6.5%	2.2%	45.5%	-2.2%
2019	Wet	2.9%	-0.7%	0	1.3%	3.5%	2.2%	-0.7%	2.8%	-90.7%	1.0%
Average		**-2.4%**	**3.7%**	**0.0%**	**-0.3%**	**2.7%**	**-0.4%**	**1.8%**	**82.9%**	**-0.1%**	**1.5%**

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4.3 Habitat Availability

4.3.1 Methods

To quantify juvenile salmonid-rearing habitat according to availability of water depth, velocity, and distance to escape cover, TRRP applied a metric of "capacity." This capacity is normalized by stream length to give a maximum number of fish that would occupy an average habitat available for a 1-meter cross section of stream over a given stream length, or *C* here after. The *C* metric has been developed over many years, involving thousands of observations and several studies (Som et al. 2017).

We assessed how *C* is affected by Winter Flow Project using flow duration analysis of the two management scenarios (see Section 3. From these two sets of hydrographs, we developed daily flow duration curves from January through June for the water years 2004 - 2019 for the Trinity River above its confluence with the North Fork Trinity River. Flow duration curves depict the likelihood of a given flow being exceeded over an amount of time ranging from 1% to 100%. These daily flow duration values were then transformed into flow-specific fry and presmolt *C*. Values were interpolated between a range of flows from 4.2 - 99.1 m^3/s (148 - 3500 cfs) with specified *C* estimates as done in Cooper et al. (*in review*).

Calculations of *C* were done independently for seven maximum fisheries flow (MFF) reaches (California Department of Water Resources (DWR) 2007), which have variable hydrology due to contributions from tributaries. We weighted *C* for each MFF reach by its respective proportion of the length of the restoration reach and summed the weighted *C* values across all seven MFF reaches. We plotted capacity duration curves with flow-specific capacity probability (x-axis) and corresponding restoration reach-scale *C* (y-axis) for each hydrologic scenario (Figure 4-6).

4.3.2 The Effect of the Winter Flow Project on Habitat Availability

The Winter Flow Project would shift restoration releases earlier in the year, resulting in the inundation of the floodplains when most juvenile fish are rearing in the restoration reach. This would be especially beneficial near Lewiston Dam, where minimal tributary inflow contributes to the Trinity River's discharge. The anticipated effects of the inundation would be more available rearing habitat, as slow water habitat and access to food resources would be more plentiful and available in the inundated floodplain earlier in the year. Figure 4-6 shows the predicted percentage change in habitat capacity for the 40-mile restoration reach (Som et al. 2017)[17] and the percentage of individual habitat units within the restoration reach predicted to have increased habitat capacity (USFWS and NOAA 2018).

In Figure 4-6, the integrated area under the curve (I) is presented next to its respective curves with matching shades of color. Using an integrated area under the curve metric Cooper et al. (*in review*) there is a respective 7.5% and 8.1% increase in fry and presmolt capacity over the entire restoration reach from the flow regime with the baseline conditions to that with the Winter Flow Project.

[17] Habitat capacity is an index of the number of juvenile Chinook Salmon that could be supported in a given area based on water depths, velocities, and distances to cover (Som et al. 2017).

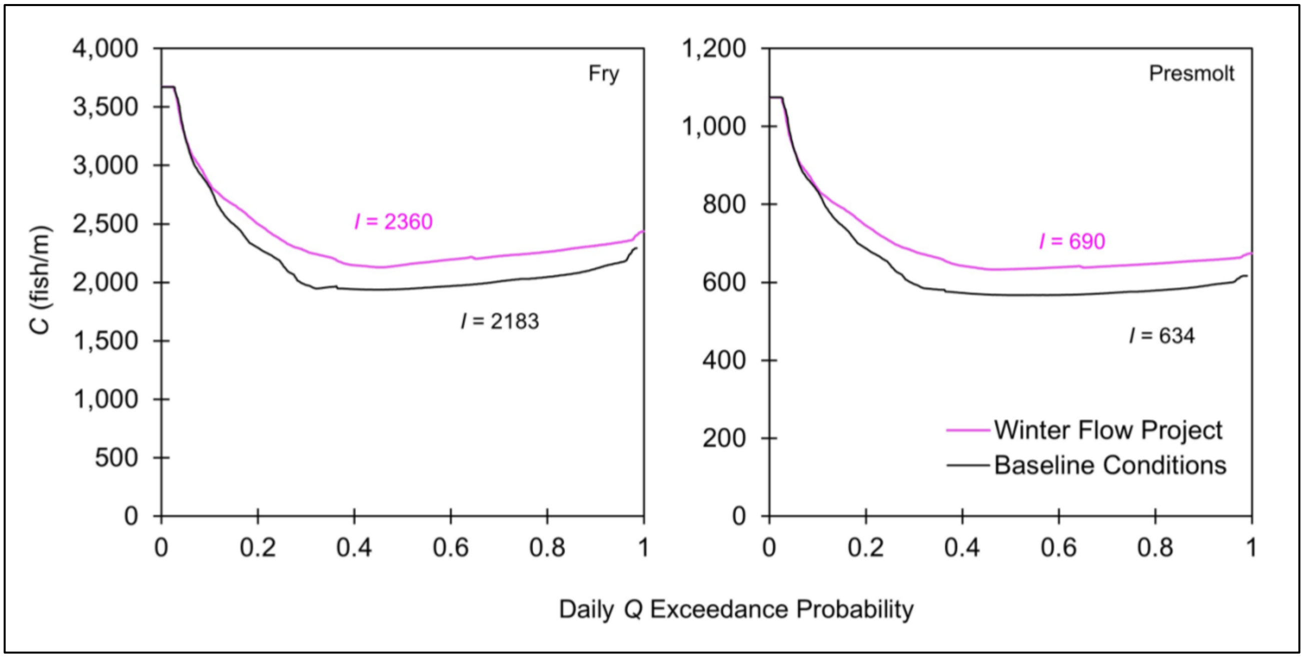


Figure 4-6. Capacity of fry (left) and presmolt (right) Chinook Salmon as it relates to flow duration for the baseline conditions and the Winter Flow Project over the entire Trinity River restoration reach.

Table 4-6. Predicted change (%) in habitat capacity for the 40-mile restoration reach, and the percentage of individual habitat units within the restoration reach predicted to have increased habitat capacity (USFWS and NOAA 2018). Changes are relative to the 300-cfs baseflow currently implemented in each year during the period targeted by the Winter Flow Project.

Discharge (cfs)	Percent Change in Predicted 40-Mile Habitat Capacity	Percent Habitat Units with Predicted Capacity Increases
300	0%	0%
500	3%	58%
700	7%	61%
900	10%	66%
1,100	14%	72%
1,300	19%	78%
1,500	25%	81%

4.4 Food Availability

4.4.1 Methods

After mobilization of the stream bed, the relative abundance of large, long-lived species or non-native species of benthic macroinvertebrates is reduced and the abundance of smaller, shorter-lived macroinvertebrates that are more available as prey for salmonids increases. This shift has been observed to result in a larger biomass of rearing juvenile salmonids and other insectivorous fish (Cross et al. 2011; Parker and Power 1997; Power et al. 2008; Wooton et al. 1996). We use thresholds that define the Shields number as greater than >0.03 and >0.045 as indicators of partial bed disturbance assumed to be sufficient to affect the benthic macroinvertebrate community

(Wilcock and McArdell 1993). Spatially explicit sheer stress values are provided by outputs from SRH-2D (Bradley 2018) for 16 flows up to the Maximum Fisheries Flow (California DWR 2007) above the confluence with the North Fork Trinity River. The Maximum Fisheries Flow (MFF) is representative of a 100-year tributary accretion event during April and May paired with a release of 11,000 cfs from Lewiston Dam and serves as the maximum allowable flow for restoration purposes (California DWR 2007). There are seven different MFF reaches that are coincident with tributary confluences that result in different hydrology and subsequently different MFF discharge values (California DWR 2007). Spatially explicit Shields numbers can then be calculated using the grain-size map produced by Alvarez et al. (2015), which covers the area of the active channel over the length of the 40-mile restoration reach.

Where Sheilds numbers exceed the thresholds denoted above, it is assumed that the bed surface either partially or fully mobilized causing mortality of a proportion of benthic macroinvertebrates living in the bed. Additionally, SRH-2D inundation areas at different flows (Bradley 2018) can be used to calculate the area of inundated floodplains and marginal habitat that would result from hypothetical hydrographs and estimate the amount of area that would be made avaialble for colinization by benthic aquatic organisms. Successional colinization of newly available habitats due to disturbance by biofilm occurs approximately 28 days after disturbance, followed by return of pioneer species of macroinvertebrates to pre-disturbance abundance in the benthos after approximately 42 days and a peek in abundance of these species above pre-disturbance levels approximately 63 days after disturbance (Merz et al. 2012).

4.4.2 Effects of the Winter Flow Project on Food Availability

The Winter Flow Project would result in increased food availability for salmonids by providing flows that are expected to scour (release some attached algae and macrophytes and associated invertebrates from their habitats) earlier in the year to increase food availability. Optimal duration of ephemeral habitat inundation to support peak invertebrate prey species availability is currently not accomplished when most juvenile salmon are foraging in the focal reach (see Section 2.5 Furthermore, hypolimnetic releases from Trinity Dam artificially lower water temperature, which increases the generation time of important prey species. Chironomidae generation time drops from 36 days to 25 days when water temps are doubled from 7.5 °C to 15 °C, with mayfly (baetidae) generation time dropping from 250 days to fewer than 100 days (Asarian et al. *in review*). As shown in Figure 4-7, earlier releases would result in more abundant prey species when juvenile salmon are present in the upper reaches of the Trinity River. The volume of flow that results from the proposed action during the synchronization and increased base-flow periods would result in earlier scour and floodplain inundation, thus providing habitat for prey species to colonize and food availability for drift foraging earlier in the season. Scour and floodplain inundation are important to provide the conditions and generation time necessary for smaller macroinvertebrates like chironomids and mayfly (baetidae) that are the preferred prey of juvenile salmon. This would potentially impact the size of juvenile fish by reducing competition for more abundant food. The compounded impacts of increased food availability and warmer temperatures (discussed in the next section) would potentially result in larger fish and earlier outmigration of juvenile fish when compared to baseline conditions. These effects would contribute to the ROD objective of rehabilitating the Trinity River's anadromous fisheries.

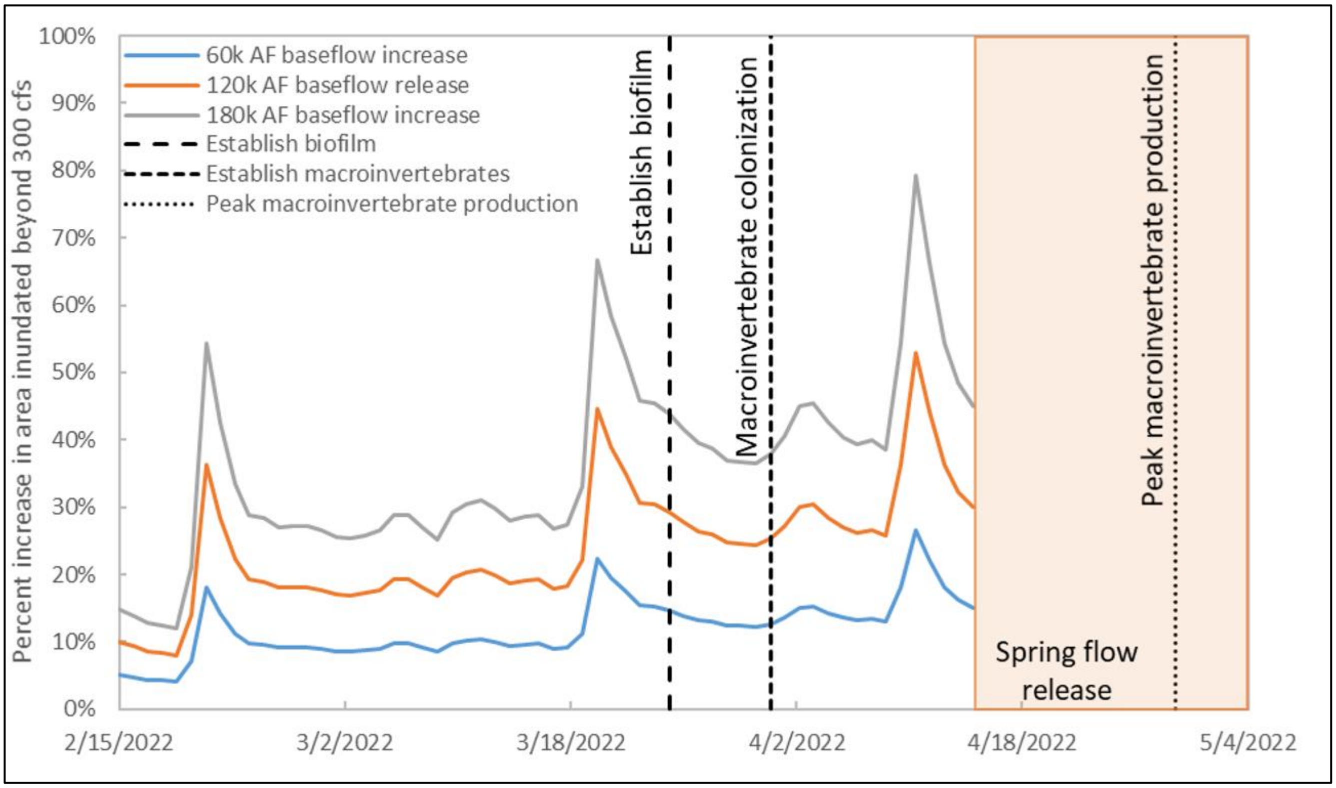


Figure 4-7. Illustration of the Winter Flow Project on the potential production of macroinvertebrates. Dashed lines occur 28, 42, and 63 days after the onset of the elevated baseflow period and indicate the benthic species successional transition.

Using Shields number >0.03, there is an estimated increase of 24% in area of bed disturbance throughout the restoration reach during years where Winter Flow Project results in a synchronized flow release between December 15 and February 15, and a range from near zero to 44.0% depending on the year and MFF reach. If a more conservative estimate of bed disturbance for Shields number >0.045 is used, the increase in area of bed disturbed by Winter Flow Project is estimated to be 13%, ranging from near zero to 22.8%. In relation to the increases shown for risk of redd scour (which is discussed below). All four reaches above Douglas City see estimated increases in area of disturbed bed of 35% for a Shields number threshold of >0.03 as well as an estimated increase in area disturbed of 18% when the more conservative threshold of Shields number >0.045 is applied (see Figure 4-8, Figure 4-9, Table 4-7, Table 4-8).

Table 4-7. Increases in proportion of streambed area with Shields numbers >0.03 for the Winter Flow Project from baseline conditions for each MFF reach for each year where a peak flow event would occur between Dec 15 - Feb 15 under the Winter Flow Project from WY 2004-2019. At the bottom is the average area of increase for all reaches, and on the right is the average for all years within each reach.

Location	2019	2017	2016	2015	2008	2006	Increase in area of streambed experiencing Shields number >0.03
Lewiston	34.7%	34.7%	34.7%	34.7%	34.7%	34.7%	34.7%
MFF Reach 2	31.7%	32.5%	33.0%	32.6%	31.4%	32.1%	32.2%
Limekiln	39.1%	39.3%	40.6%	38.3%	37.1%	13.8%	34.7%
MFF Reach 4	44.0%	42.5%	44.8%	42.5%	40.2%	-1.7%	35.4%
Douglas City	39.2%	20.9%	7.9%	9.2%	35.7%	-0.2%	18.8%
Junction City	22.9%	13.9%	1.6%	0.1%	17.4%	0.0%	9.3%
Abv North Fork	9.6%	-0.1%	1.1%	0.1%	11.8%	0.0%	3.7%
Average	**31.6%**	**26.2%**	**23.4%**	**22.5%**	**29.8%**	**11.2%**	**24.1%**

Table 4-8. Increases in proportion of streambed area with Shields numbers >0.045 for the Winter Flow Project from baseline conditions for each MFF reach for each year where a peak flow event would occur between Dec 15 - Feb 15 under the Winter Flow Project from WY 2004-2019. At the bottom is the average area of increase for all reaches, and on the right is the average for all years within each reach.

	2019	2017	2016	2015	2008	2006	Increase in area of streambed experiencing Shields number >0.045
Lewiston	18.4%	18.4%	18.4%	18.4%	18.4%	18.4%	18.4%
MFF Reach 2	17.5%	18.0%	18.4%	18.1%	17.3%	17.8%	17.9%
Limekiln	18.5%	18.6%	19.4%	18.1%	17.4%	7.3%	16.6%
MFF Reach 4	21.8%	21.0%	22.2%	21.0%	19.9%	1.6%	17.9%
Douglas City	22.8%	15.0%	7.4%	7.5%	19.9%	0.0%	12.1%
Junction City	15.2%	10.2%	2.8%	0.2%	10.7%	0.0%	6.5%
Abv North Fork	8.2%	2.8%	1.7%	0.1%	10.6%	0.0%	3.9%
Average	**17.5%**	**14.9%**	**12.9%**	**11.9%**	**16.3%**	**6.4%**	**13.3%**

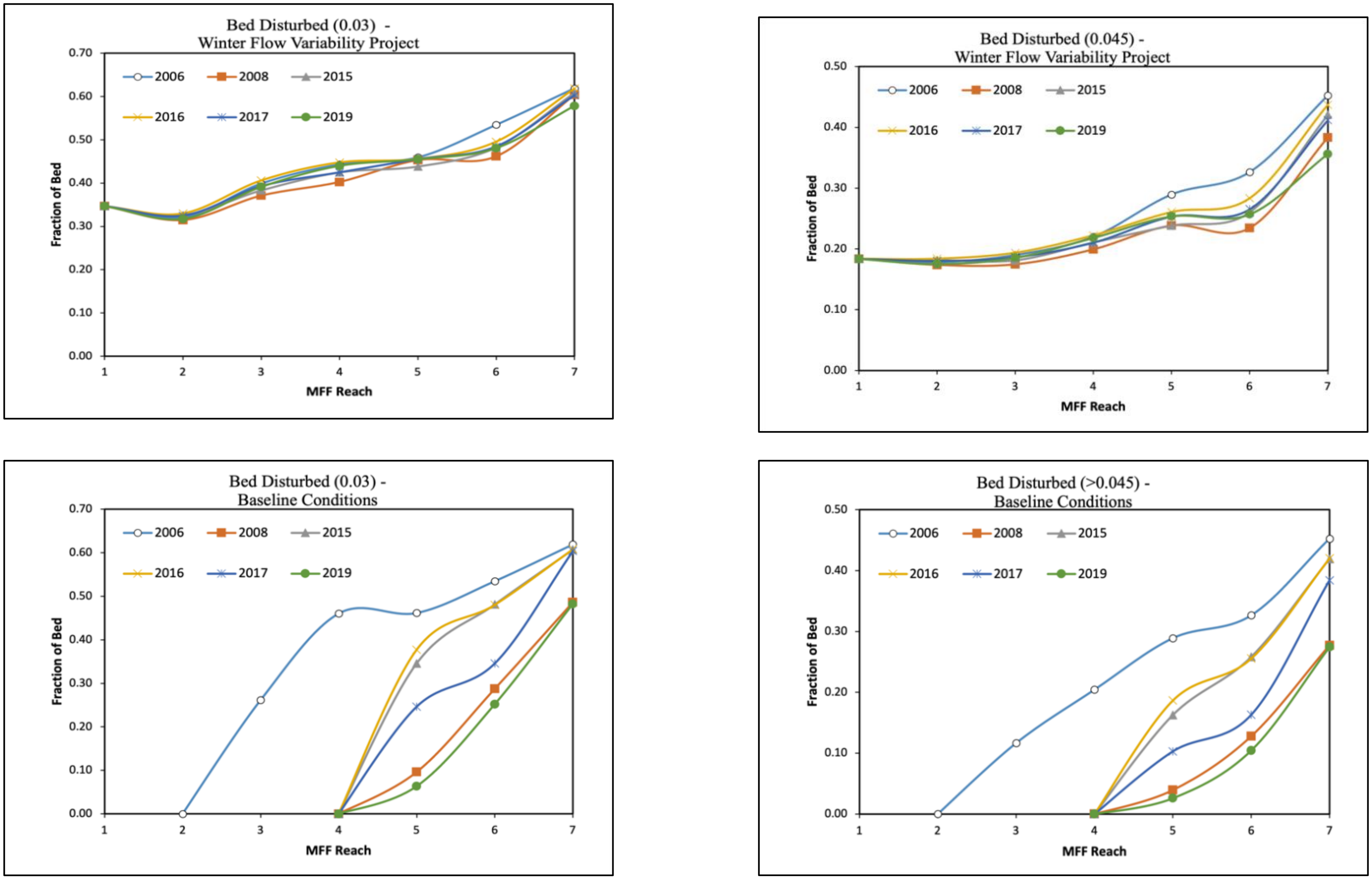


Figure 4-8. Fraction of the streambed that experiences partial mobilization as indicated by Shields numbers >0.03 (left) and >0.045 (right) for the Winter Flow Project (top) and baseline conditions (bottom) in the 6 years between 2004 and 2019 when a synchronized flow release would have been triggered.

4.5 Redd Scour

A possible source of mortality for salmonids from elevated flows during the period where salmonid eggs are incubating in gravels (September - April) is from redd scour, excavation of salmonid eggs, or underdeveloped fry during floods prior to natural emergence from gravels. Peak flows on unregulated rivers in our region primarily occur during the incubation period based on an expectation from biologists that, through evolution and natural selection, salmonids have behavioral practices that mitigate this risk in a natural environment. However, the environment on the Trinity River has been modified in several ways, and it is prudent to examine the change in potential risk of redd scour from the Winter Flow Project.

4.5.1 Methods

The set of triggers used to develop hypothetical hydrographs generated for analysis of the impacts of Winter Flow Project only result in synchronized peak flow events during the incubation period in six of the 17 years analyzed. To expand our analysis to the entirety of the restoration reach between Lewiston Dam and the Trinity Rivers confluence with the North Fork Trinity River, we used the methods and findings of May et al. 2007 in combination with the Trinity River 40-mile SRH-2D hydrodynamic model (Bradley 2018).

Important assumptions related to the relative risk of redd scour are associated with the depth at which salmonid eggs are deposited and the Shields number, which describes the forces acting on the median grain size of the streambed and is used to predict when the streambed will be mobilized and the potential depth to which it can be scoured. Additional details about the methods used to generate spatially explicit Shields number are described in Section 4.4.1 and its computation can be found in May et al. (2007) or in any textbook on fluvial geomorphology or sediment transport engineering. We adopt thresholds from literature that assume the streambed begins to move at Shields numbers >0.03, the bed is partially mobile at values >0.045, and the bed is fully mobile and potentially subject to deep scour when the Shields number exceeds 0.06. Using these thresholds paired with spatially explicit shields number (calculated from sheer stress provided by Bradly 2018 and grain-size derived from Alvarez et al. 2015) the area of the perennially wetted streambed that experiences a Shields number above these thresholds can be calculated (Figure 4-9). However, using methods described by May et al. 2009 to predict the risk of scour and fill of salmon redds, it was determined that the risk of scour deep enough to excavate incubating salmon eggs in the Trinity River is only 4% for locations with Shields numbers between 0.045 and 0.06, and 7% for locations with Shields numbers >0.06. Using redd locations from 2012 and 2014 (Rupert et al. 2017) paired with spatially and discharge explicit results for Shields number and the resulting likelihood of deep bed scour described by May et al. (2009) the proportion of redds at risk of scour during years where a synchronization event occurred for each MFF reach and throughout the 40-mile restoration reach can be estimated (Table 4-9).

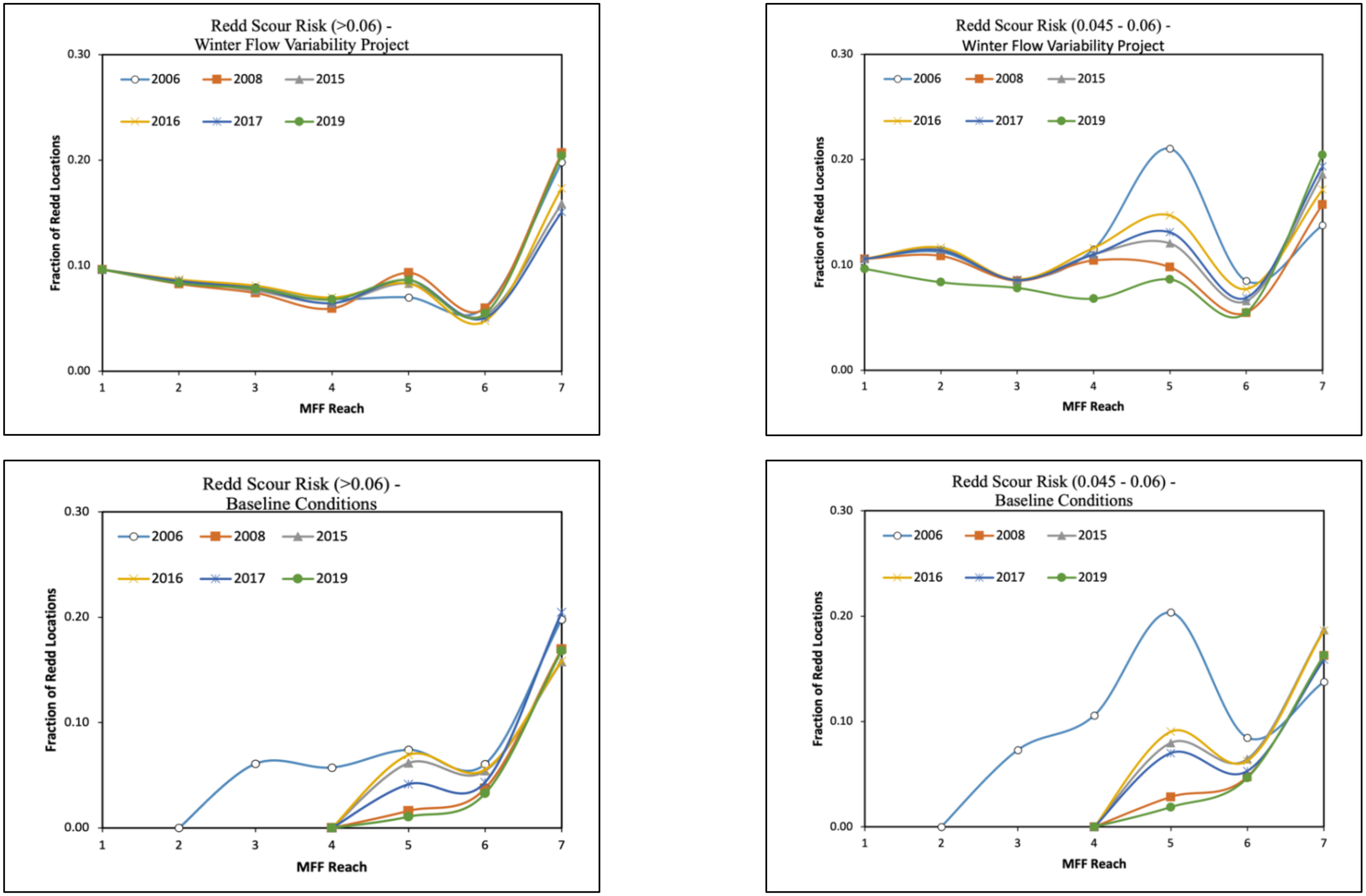


Figure 4-9. Fraction of Redd locations from 2012 and 2014 in each MFF reach where the streambed experiences Shields numbers greater than >0.06 (left) and 0.045-0.06 (right) for the Winter Flow Project (top) and baseline conditions (bottom) in the 6 years between 2004 and 2019 when releases would have been triggered during the action period.

4.5.2 Effects of Scour on Salmon Redds

The proportion of the spawned area of the streambed where Shields numbers increase to >0.045 for the Winter Flow Project increases over that in the baseline conditions is estimated to be 11.6%. This results in an increased risk of redd scour of 0.7% for the population of redds within the restoration reach. The sub-reach with the most increased risk from Winter Flow Project is directly below Lewiston Dam, where 20.2% spawned area experiences Shields numbers >0.045. These Shields numbers are due to flows related to the Winter Flow Project resulting in an increased risk of redd scour for the population of redds upstream of Rush Creek of 1.1% (see Table 4-9 and Table 4-10 for details).

Table 4-9. Increases in proportion of spawned streambed area with Shields numbers >0.06 and increase in risk of redd scour using probabilities from May et al. 2009 for the Winter Flow Project compared to baseline conditions for each MFF reach for each year where a synchronized peak flow event would have occurred during the incubation period under the Winter Flow Project from WY 2004-2019.

Winter Flow Project	2019	2017	2016	2015	2008	2006	Increase in redd locations with Shields >0.06	Risk of Redd Scour
Lewiston	9.6%	9.6%	9.6%	9.6%	9.6%	9.6%	9.6%	0.7%
MFF Reach 2	8.4%	8.6%	8.7%	8.6%	8.3%	8.5%	8.5%	0.6%
Limekiln	7.8%	7.8%	8.1%	7.7%	7.4%	1.9%	6.8%	0.5%
MFF Reach 4	6.8%	6.5%	7.0%	6.5%	6.0%	1.1%	5.6%	0.4%
Douglas City	7.6%	4.5%	1.4%	2.2%	7.7%	-0.4%	3.8%	0.3%
Junction City	2.2%	0.7%	-0.8%	-0.1%	2.2%	0.0%	0.7%	0.0%
Abv North Fork	3.6%	-5.4%	1.5%	0.1%	3.7%	0.0%	0.6%	0.0%
Avg	**6.6%**	**4.6%**	**5.1%**	**4.9%**	**6.4%**	**3.0%**	**5.1%**	**0.4%**

Note: At the bottom of the table, is the average area of increase for all reaches and on the right is the average for all years within each reach. The column on the far right uses 7% value for the risk of redd scour from May et al. (2009) for bin of Shields numbers >0.06 to assess the risk to the entire population of redds.

Table 4-10. Increases in proportion of spawned streambed area with Shields numbers 0.045 - 0.06 and increase in risk of redd scour using probabilities from May et al. 2009 for the Winter Flow Project from the baseline conditions for each MFF reach for each year where a peak flow event would have occurred during the incubation period under the Winter Flow Project from WY 2004-2019.

Winter Flow Project	2019	2017	2016	2015	2008	2006	Increase in redd locations with Shields 0.045-0.06	Risk of Redd Scour
Lewiston	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%	0.4%
MFF Reach 2	11.0%	11.4%	11.7%	11.5%	10.9%	11.2%	11.3%	0.5%
Limekiln	8.6%	8.6%	8.6%	8.5%	8.5%	1.3%	7.3%	0.3%
MFF Reach 4	11.4%	11.0%	11.6%	11.0%	10.4%	0.9%	9.4%	0.4%
Douglas City	11.3%	6.1%	5.7%	4.1%	6.9%	0.7%	5.8%	0.2%
Junction City	1.7%	1.6%	1.4%	0.1%	0.7%	0.0%	0.9%	0.0%
Abv North Fork	-0.8%	3.5%	-1.5%	-0.1%	-0.5%	0.0%	0.1%	0.0%
Avg	**7.7%**	**7.5%**	**6.9%**	**6.5%**	**6.8%**	**3.5%**	**6.5%**	**0.3%**

Note: At the bottom of the table is the average area of increase for all reaches and on the right is the average for all years within each reach. The column on the far right uses 4% value for the risk of redd scour from May et al. (2009) for bin of Shields numbers from 0.045-0.06 to assess the risk to the entire population of redds.

4.6 Summary of the Winter Flow Project's Potential Effects to Salmon Fisheries

If realized, these modeled effects of the Winter Flow Project would help the TRRP meet ROD objectives to rehabilitate the Trinity River's anadromous fisheries, when compared to baseline conditions. The Winter Flow Project would result in increased juvenile rearing habitat and food availability and would influence the river's temperature so the Fish Workgroup's proposed juvenile rearing temperature range would be met, thus encouraging earlier outmigration of juvenile salmon, and positively impacting juvenile growth.

Under Winter Flow Project, the Trinity River would experience warmer temperatures earlier in the summer while degree-day exceedances for holding adults at Douglas City in July and early September would increase by a marginal and not biologically meaningful amount above the baseline conditions. There would be no change to compliance with the late September target at Douglas City or the October to December target at the North Fork because there would be no change to flows during this period. Potential synchronized releases between December 15 and 30 would not affect temperature compliance because ambient river temperatures and releases from Lewiston Dam are well below the target temperature at that time.

As a portion of restoration releases would be shifted earlier in the year, releases would better match natural tributary runoff and would reduce the duration of temperature suppression that occurs under existing April - July restoration releases. The effects of shifting water volume earlier in the year include increased juvenile rearing habitat availability and more rapid juvenile growth resulting from increased availability of food and higher metabolism. Warmer temperatures would not only increase prey species abundance but also the ability of juvenile fish to consume and benefit from increased prey availability.

Conditions for fish growth would improve as the Winter Flow Project would allow nursery areas to be inundated and begin warming earlier in the season and decrease temperature suppression from cold water dam releases by scaling down the amount of water released during the critical growth period. This would help river temperatures to reach the Fish Workgroup's proposed target range for juvenile rearing.

Based on models run to compare the Winter Flow Project and baseline conditions, it is expected that the overall result of the Project's effect on temperature would be larger fish earlier in the season, and the potential of earlier outmigration of juvenile fish. The Winter Flow Project would result in greater mass by the end of June when compared to baseline conditions. The differences in daily growth rate of juvenile Chinook Salmon between the baseline conditions and Winter Flow Project are smaller in drier water years than wetter water years.

5. Analysis of Effects on Non-Fisheries Resources

Non-fisheries resources that may be affected by the Winter Flow Project include geomorphology, hydrology and flooding, water quality, vegetation, fisheries resources, recreation, and power and utilities. The effects analysis for the baseline conditions and Winter Flow Project for each resource topic is based on the application of the best available science and employs the use of models and analysis of existing data to determine potential effects for these resources.

5.1 Geomorphology and Soils

5.1.1 Baseline Conditions

Millions of cubic yards of mining debris were washed into the Trinity River from upslope hydraulic mines over a 60-year period ending in the 1930s. The era of hydraulic mining was followed by large-scale cable and then bucket line dredge mining of the alluvial valley floor into the 1950s. The channel and Trinity River floodplain were dredged extensively, and enormous piles of mining waste called “dredge tailings” are evident on both sides of the river throughout the river corridor.

Beginning in the early 1960s, the Trinity River was regulated by Trinity and Lewiston dams. Water and power diversions of up to 88% of the Trinity River to the Sacramento River basin in the 1960s and 1970s led to substantial floodplain changes along the Trinity River as the channel narrowed from vegetation encroachment that caused sediment to deposit in berms along the river’s edge (USFWS and HVT 1999). Reservoirs associated with the dams also captured sediment from the upper watershed, and the regulated river no longer had a sediment supply at Lewiston. These impacts simplified the river channel, reduced the extent of its floodplain and ecologically functioning areas, and negatively impacted local salmon and foothill yellow-legged frog populations.

5.1.2 Analysis of Winter Flow Project on Bedload Transport

Bedload transport is a form of sediment movement that involves sand, gravel, and cobbles rolling or bounding downstream along the streambed. Bedload transport has been used to describe the geomorphic character of various Trinity River reaches and to monitor changes along the river since the TRFES (USFWS and HVT 1999). In general, upper reaches of the Trinity River within the study area, near Lewiston Dam, experience less bedload transport than the lower reaches due to reduction of flood magnitudes and a lower supply of sediment than downstream reaches, which receive sediment and water from tributaries.

The Winter Flow Project would benefit the Trinity River fisheries, as sediment that is supplied to the river from tributaries would be more rapidly dispersed downstream to maintain fish migration pathways into and out of tributaries. This would happen due to elevated dam releases occurring simultaneous with tributary runoff events instead of occurring months later after tributary runoff has receded. The increased mainstem flow events that would result from synchronization of restoration releases with natural tributary runoff would increase scour of the active channel to clear pathways for flow through gravels, which would benefit salmon egg incubation, promote a diverse assemblage of riparian vegetation and river meandering, and increase bedload transport.

5.1.2.1 Bedload Transport Analysis

Bedload transport (in tons) in winter under baseline conditions and during the Flow Synchronization Period of the Winter Flow Project were estimated at Lewiston, Limekiln Gulch, and Douglas City using methods from Buxton

(2021). The estimates were made for the same period (December 15 to February 15) in water years 2006, 2008, 2015, 2016, 2017, and 2019, using River Basin Model-10 (RBM10) flows projected at these stations for each alternative (Jones et al. 2016). The results indicated discharges under the Winter Flow Project would transport a substantially larger mass of sediment than discharges that would occur if baseline conditions were maintained (Table 5-1).

Table 5-1. Bedload yield (in tons) estimated for baseline conditions and Winter Flow Project.

Water Year	Lewiston		Limekiln Gulch		Douglas City	
	Baseline Conditions	Winter Flow Project	Baseline Conditions	Winter Flow Project	Baseline Conditions	Winter Flow Project
2006	0	247	43	485	1372	3780
2008	0	269	0	290	34	1524
2015	0	133	>1	281	262	1594
2016	0	136	4	372	242	4051
2017	0	276	5	263	397	5208
2019	0	173	2	156	39	2603

5.1.2.2 Coarse Bedload Analysis

Coarse bedload transport (downstream transport of particles >8 mm B-axis diameter) has been used as a surrogate to measure geomorphic work accomplished by prescriptive environmental flows since the time of the TRFES (USFWS and HVT 1999) Many hypotheses have been presented about how increases in coarse bedload transport would result in increases in juvenile salmonid rearing habitat through planform change and transport of large delta deposits. However, these hypotheses have not been verified since implementation of the ROD in 2004. Coarse bedload yield is presented here to disclose possible impacts of Winter Flow Project on both the environment and the progress towards ROD objectives.

To understand changes to bedload transport that may occur under the Winter Flow Project, coarse bedload transport potential was estimated at various locations along the Trinity River from Lewiston Dam to the North Fork Trinity River under the baseline conditions and the Winter Flow Project. Coarse bedload mobilized during water years 2004 through 2019 was estimated for baseline conditions and Winter Flow Project using daily average flows predicted by RBM10 (Table 5-2). Bedload was calculated using 2015 sediment rating curves (Gaeuman and Stewart 2017) for the reaches where rating curves existed. Where information was not available, the nearest sediment rating curve was applied. This resulted in the most downstream rating curve, located near Douglas City, being applied to the two subsequent downstream reaches.

Under the Winter Flow Project, synchronization of elevated ROD flow releases with tributary flow events would increase river flows that could transport bedload and mobilize delta deposits during the period when sediments were being recruited to the channel from tributaries. These effects are expected to increase juvenile fish habitat along the lower reaches of the Trinity River by shaping sediment into bars and floodplain deposits. Potential bedload transport at lower reaches would aid to create a more natural meandering river form, where shallow floodplain features could be inundated during the synchronized flow and elevated baseflow periods to provide rearing habitat.

Modeling of bedload transport indicates that the Winter Flow Project would result in a slight decrease in coarse bedload transport in reaches upstream of Grass Valley Creek, cause no change between Grass Valley and Indian

creeks, and increase transport downstream of Reading Creek (Figure 5-1). There is a general increase in the downstream direction for coarse bedload transported, with the notable exception of the Grass Valley Creek to Indian Creek Reach (Figure 5-1 and Table 5-2). The differences between the baseline conditions and the Winter Flow Project vary by water year and location, but generally, over the entire period analyzed, the Winter Flow Project results in a decrease in coarse bedload mobilized for upstream reaches and an increase for downstream reaches, with the transition occurring near Douglas City. However, the timing of bedload movement differed, with the Winter Flow Project transporting bedload both in the winter during accretion events when tributaries are supplying bedload to the mainstem and in the spring when ROD releases have traditionally mobilized the streambed under baseline conditions.

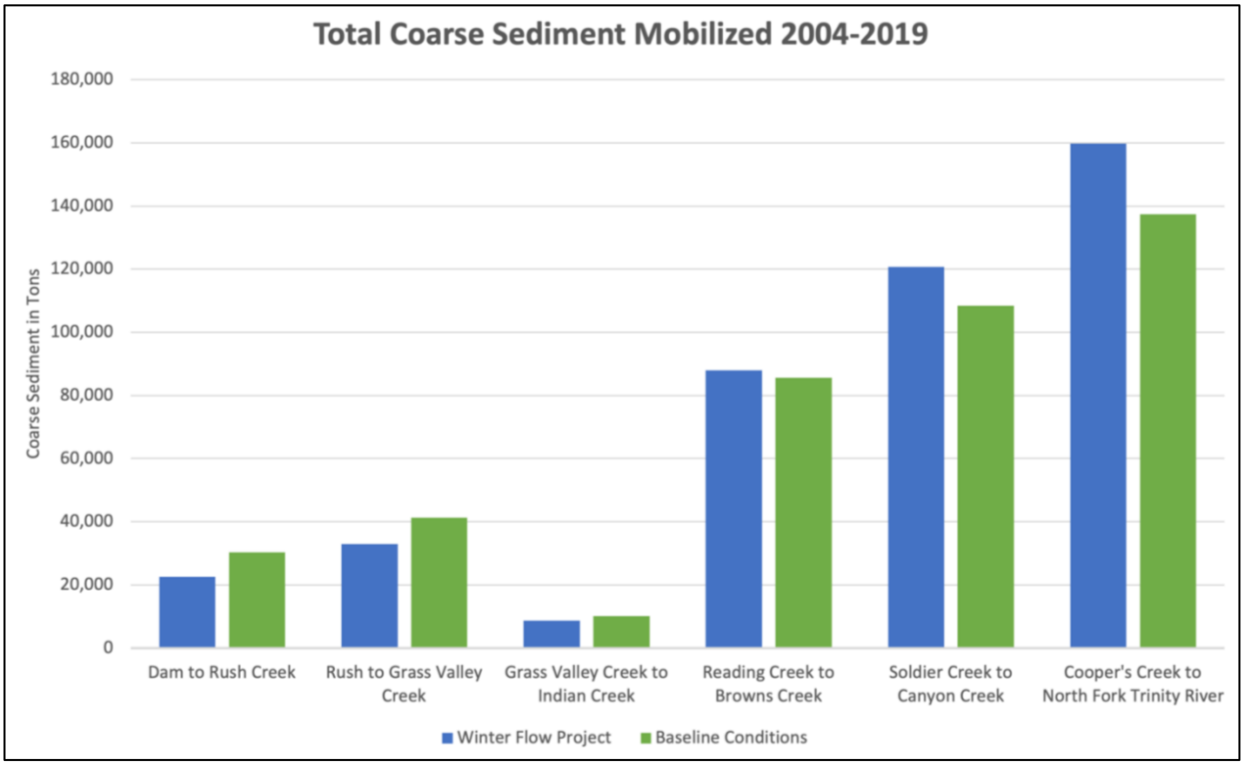


Figure 5-1. Total course sediment mobilized 2004 – 2009. Actual (Baseline Conditions – green) and hypothetical (Winter Flow Project – blue) bedload transport at six locations.

Table 5-2. Estimates of coarse bedload mobilized during water years 2004-2019 for baseline conditions (BC) and the Winter Flow Project using daily average flows predicted by RBM10.

Water Year	Lewiston to Rush Creek		Rush Creek to Grass Valley Creek		Grass Valley Creek to Indian Creek		Reading Creek to Browns Creek		Soldier Creek to Canyon Creek		Cooper's Bar to the North Fork Trinity River	
	Winter Flow Project	BC	Winter Flow Project	BC	Winter Flow Project	BC	Winter Flow Project	BC	Winter Flow Project	BC	Winter Flow Project	BC
WY2004	255	422	709	1,083	245	344	4,686	4,395	6,463	5,477	8,667	6,987
WY2005	2,079	600	3,169	1,404	812	470	6,606	5,835	7,791	7,227	9,060	8,679
WY2006	4,251	7,458	6,364	10,456	1,707	2,533	17,014	19,151	25,052	24,907	34,823	32,392
WY2007	4	18	27	123	13	55	658	1,348	928	1,570	1,277	1,857
WY2008	442	373	1,118	932	375	304	4,863	3,853	5,691	4,310	6,546	4,804
WY2009	2	8	26	85	14	46	791	1,379	1,125	1,772	1,541	2,230
WY2010	433	434	1,069	1,077	365	365	5,080	5,024	6,420	6,098	7,847	7,251
WY2011	5,378	9,905	6,648	11,156	1,512	2,309	9,980	11,781	12,493	13,402	15,228	15,238
WY2012	159	160	548	514	222	190	4,248	3,522	5,620	4,323	7,190	5,330
WY2013	2	4	15	46	8	23	513	888	679	1,039	902	1,239
WY2014	0	0	0	0	0	0	93	69	181	111	297	177
WY2015	548	793	975	1,216	290	301	3,408	2,298	4,740	2,824	6,293	3,571
WY2016	1,950	1,881	3,113	2,857	857	720	8,912	6,407	12,476	8,303	16,800	10,936
WY2017	5,830	6,794	7,215	8,161	1,659	1,816	13,853	13,131	20,291	17,926	28,254	24,208
WY2018	0	0	0	0	0	0	197	148	419	289	713	495
WY2019	1,175	1,376	1,880	2,217	512	598	6,985	6,423	10,348	8,848	14,414	11,937
SUM for WY	22,508	30,226	32,875	41,328	8,593	10,076	87,888	85,651	120,718	108,425	159,852	137,331
% Baseline Conditions	**74**		**80**		**85**		**103**		**111**		**116**	

Note: Reaches are ordered from upstream to downstream, moving from left to right. Bedload was calculated using 2015 sediment rating curves from Gaeuman and Stewart (2017), using the rating curve most applicable to the reach. Where information was not available, the nearest bedload rating curve was applied, resulting in the most downstream rating curve, located near Douglas City, being applied to the two reaches further downstream.

It is unclear how these changes would influence progress toward the objectives outlined in the ROD. Geomorphic conditions that support habitat are relatively plentiful in upstream reaches compared to downstream reaches. Under the Winter Flow Project, increasing geomorphic work in lower reaches by synchronizing dam releases with tributary accretion to address habitat bottlenecks could be a desirable outcome that would improve habitat in lower reaches. However, the models indicate that deltas targeted for mobilization occurring in the upper reaches where there is an overall decrease in estimated coarse bedload transport under the Winter Flow Project may experience less transport. It is unclear if timing flow releases with tributary sediment mobilization will more efficiently transport delta deposits, or if reduced flow volumes during spring geomorphic releases will result in less effective mobilization of these same sediments. In addition, spring release volume distribution will be subject to the discretion of the TRRP Flow Workgroup, the TMC, and Reclamation, and could be redistributed or prioritized under the Winter Flow Project to better accomplish geomorphic work than the hypothetical hydrographs that were developed for this analysis.

5.2 Hydrology and Flooding

5.2.1 Baseline Conditions

The study area for the hydrology and flooding analysis is the 100-year floodplain, which is defined as the area that has a 1% annual chance of flooding and is measured along the Trinity River as 11,000 cfs at Lewiston Dam and 94,830 cfs just downstream of the North Fork tributary (FEMA 2014). Under the ROD, releases from Lewiston Dam are not to exceed 11,000 cfs.

To support restoration flows in the early 2000s, the TRRP cleared the floodplain of structures (e.g., bridges, pump houses, and buildings) to accommodate the Maximum Fisheries Flow (MFF;[18] California DWR 2007). The MFF zone is smaller than the 100-year floodplain at any given location along the Trinity River, except at Lewiston Dam, where they coincide (Table 4.4-1 from the Master Environmental Impact Report [EIR] shows the MFF at intervals along the Trinity). Protection of the MFF also ensures that structures within the larger 100-year floodplain are protected from flooding.

5.2.2 Analysis of Winter Flow Project on Hydrology

5.2.2.1 Restoration Release Volume and Timing

Elevated ROD releases above baseflow under the Winter Flow Project would occur in phases beginning as early as December 15 and extending through late spring/early summer, based on water year type, to release the full ROD volume (see Figure 3-3). In spring, the TRRP would determine the Lewiston Dam release schedule for spring restoration (ROD flow) releases based on the predicted water year type and on predicted winter runoff events, as described in Section 3.3 . The volume of restoration releases would not be changed from baseline conditions and would remain the same as stipulated in the ROD and outlined in Table 3-1.

Because winter releases would occur in several early winter-spring phases rather than one larger ROD peak release in May and June, the result would be multiple pulses that are shorter in duration between December 15

[18] The MFF is defined as the 11,000 cfs release from Lewiston Dam plus Spring Tributary 100-year flows at any point on the Trinity River. The area corresponding to flow was cleared during the early years of the TRRP so 11,000 cfs flows could be safely released without flooding infrastructure along the river.

and July 1, rather than the larger volume release in early summer under baseline conditions. The river would return to the summer baseflow of 450 cfs by late May or early June in dry years and by July in all year types (Figure 3-3). Under baseline conditions, the summer baseflow period of 450 cfs is typically reached in mid-July. The Winter Flow Project would therefore result in a change to the timing of winter, spring, and summer flow volumes. More water would be released in the winter. The overall volume of water released as restoration flows during the water year from Lewiston Dam, however, would remain the same as the baseline conditions (see Table 3-1). The river flows would not fall below the summer baseflows of 450 cfs and winter baseflows of 300 cfs.

5.2.2.2 Flood Potential

The Winter Flow Project would abide by the MFF used for spring ROD releases. Therefore, permitted structures above the MFF would be protected from flooding, as the cumulative winter flow (dam release plus winter run-off) would never exceed the MFF. Winter flow releases would be timed with natural winter runoff and precipitation events using NOAA's CNRFC-HEFS prediction for the Trinity River at the USGS mainstem gage above the North Fork (see Section 3.3) to avoid surpassing MFF boundaries at all locations along the Trinity River and to ensure peak flow from Lewiston Dam would not contribute to flooding of property, roads, or facilities.

Between December 15 and February 15, ROD water equivalent to 60,000 af would be released from Lewiston Dam when forecasting tools at the USGS mainstem gage above the North Fork anticipate river levels of 4,500 to 12,000 cfs. The maximum flow from Lewiston Dam during this period would not exceed 6,500 cfs, so inundation downstream of the dam would remain within the MFF limits. If the flow forecast exceeds 12,000 cfs, the synchronized flow would not be released until the receding limb of the flow event is predicted to be 12,000 cfs or less at the USGS mainstem gage above the North Fork. This conservative approach would avoid impacts to downstream properties and structures because there would no longer be uncertainty in the peak magnitude of the flow event. Flow release magnitude and "trigger" thresholds should be reevaluated as new information becomes available and floodway infrastructure constraints change.

The TRD uses safety dam releases to avoid damage to the Lewiston and Trinity dams during wetter years. These releases do not result in flooded property but result in spikes in flow that are outside of the ROD volumes. The Winter Flow Project would take advantage of winter runoff events and may result in a lower likelihood of these "safety-of-dam" releases being necessary in wetter years.

5.3 Vegetation

5.3.1 Baseline Conditions

The 40-mile reach of the Trinity River below Lewiston Dam supports a diversity of plant communities and wildlife habitats. The study area for vegetation includes the 100-year floodplain, where restoration flows under the ROD occur. Dominant habitat types in the project area include riverine, montane riparian, non-native and invasive annual grassland, and barren. Dominant overstory plant species in these 17 habitats are listed in Table 5-3.

Historic mining has resulted in the loss of riparian vegetation, along with topsoil that supported pre-mining riparian communities. While the pre-mining vegetation characteristics of the Trinity River valley are unknown, the extent and diversity of riparian communities has certainly been reduced due to human activities. In addition to loss of riparian habitat, the dynamics of riparian communities in relation to the river have shifted. Riparian encroachment along the river has contributed to the simplified channel form that resulted from the lack of scouring peak flows between the 1960s and 1990s. As discussed in Section 4.1 , reduced high flows and scour

allow for encroachment of vegetation and contribute to simplified river morphology. One of the TRRP's management objectives under the ROD is to expand and increase the complexity of the Trinity River riparian corridor and to reverse riparian encroachment, which it has made considerable progress toward achieving. These management objectives are now met through TRRP channel rehabilitation and revegetation efforts in combination with scouring of the active channel via ROD flows.

Table 5-3. Plant communities and other habitats in the Project area (HVTFD, and McBain Associates 2022).

California Wildlife Habitat Relationships	Acres	Percent of Project Reach	Dominant Species
Riverine	468	25	Open water (Trinity River and tributaries)
Montane Riparian	461	24	Fragrant sumac (*Rhus trilobata*), bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus trichocarpa*), black walnut (*Juglans hindsii*), blue elderberry (*Sambucus nigra*), California grape (*Vitis californica*), virginsbower (*Clematis* sp.), Indian rhubarb (*Darmera peltata*), mugwort (*Artemisia douglasiana*), narrowleaf willow (*S. exigua*), dusky willow (*S. melanopsis*), Oregon ash (*Fraxinus latifolia*), red willow (*S. laevigata*), rose (*Rosa* sp.), shining willow (*S. lucida*), straggly gooseberry (*Ribes divaricatum*), western goldenrod (*Euthamia occidentalis*), white alder (*Alnus rhombifolia*), western chokecherry (*Prunus virginiana*).
Annual grassland / non-native	224	12	Yellow starthistle (*Centaurea solstitialis*), Maltese starthistle (*C. melitensis*), creeping bentgrass (*Agrostis stolinifera*), redstem filaree (*Erodium cicutarium*), Himalayan blackberry (*Rubus armeniacus*), other non-native species.
Barren	181	9	California brickellbush (*Brickellia californica*), dog fennel (*Anthemis arvensis*), sweet clover (*Melelotus* sp.), Oregon goldenaster (*Heterotheca oregona*), Parry's rabbit brush (*Chrysothamnus parryii*), tailings piles and open/no vegetation.
Urban	139	7	Human disturbances and roads.
Ponderosa Pine	127	7	Ponderosa pine (*Pinus ponderosa*).
Valley Foothill Riparian	101	5	Arroyo willow (*Salix lasiolepis*) and Fremont cottonwood (*Populus fremontii*).
Montane Hardwood	55	3	Madrone (*Arbutus menziesii*), Oregon white oak (*Quercus garryana*), California black oak (*Q. kelloggii*), canyon live oak (*Q. chrysolepis*).
Douglas-fir	53	3	Douglas-fir (*Pseudotsuga menziesii*).
Blue Oak-Foothill Pine	40	2	Foothill pine (*Pinus sabiniana*), canyon live oak.
Montane Hardwood-Conifer	27	1	Bigleaf maple (*Acer macrophyllum*), mountain maple (*A. spicatum*), white oak (*Q. alba*), ponderosa pine.

California Wildlife Habitat Relationships	Acres	Percent of Project Reach	Dominant Species
Mixed Chaparral	12	1	Wedgeleaf ceanothus (*Ceanothus cuneatus*), whiteleaf Manzanita (*Arctostaphylos* sp.), coyote brush (*Baccharis pilularis*).
Lacustrine	9	<1	Open water (lakes and ponds).
Freshwater Emergent Wetland	7	<1	Cattail (*Typha angustifolia*, *T. domingensis*, *T. latifolia*), rushes (*Juncus effusus*, *Juncus* sp.), nut sedge (*Cyperus* sp.), reed canary grass (*Phalaris arundinacea*), sedge (*Carex* sp.).
Perennial Grassland	4	<1	Blue wild rye (*Elymus glaucus*), other native grasses.
Klamath Mixed Conifer	<1	<1	Incense cedar (Ca*locedrus decurrens*).
Mixed Hardwood-Conifer	<1	<1	Foothill pine, white oak (*Quercaus alba*)
Grand Total	**1,908**	**100**	

5.3.2 Analysis of Winter Flow Project on Riparian Recruitment

Under Winter Flow Project, winter flow releases are expected to help scour the channel while also reducing formation of sediment berms along the channel that result in encroachment and simplified channel morphology. More deposition and frequent inundation of the floodplain may allow native riparian species to better compete with less desirable, invasive, and non-native species such as yellow starthistle and Himalaya berry, for establishment in freshly disturbed areas like channel rehabilitation sites.

The TRRP prioritizes native tree species for recruitment and uses the Tool for Achieving Riparian Germination and Establishment of Target Species (TARGETS) model to estimate the number of nodes ("inflection points") on a cross-section across a valley bottom where riparian hardwood seedlings will be established, given scenarios of environmental conditions and management actions. For this evaluation, the TARGETS model was used to assess black cottonwood recruitment for both scenarios from 2004 - 2019 at 34 cross sections from nine areas that were distributed throughout the restoration reach from Lewiston Dam to the Trinity Rivers confluence with the North Fork Trinity River near Helena, CA.

The analysis for riparian recruitment utilizes black cottonwood as an indicator species, as it is a desirable native riparian species that has been observed over time to recruit along the Trinity River. Note that the TRRP does not have objectives for riparian recruitment during Critically Dry and Dry years, and the analysis is therefore limited to Normal, Wet, and Extremely Wet years.

Figure 5-2 and Figure 5-3 show modeled results for black cottonwood recruitment under baseline conditions and the Winter Flow Project between 2004 and 2019 at nine locations along the reach between Lewiston Dam to the confluence with the North Fork Trinity River (see Figure 1-1).

Overall, the hydrographs analyzed for Winter Flow Project would potentially decrease black cottonwood recruitment for all water year types except for Critically Dry and Extremely Wet when considering all bank elevations, and generally would lower the bank position of recruitment when compared to the baseline conditions. Notably, however, recruitment would potentially increase for targeted bank elevations in targeted water year types. Figure 5-2 and Figure 5-3 show analysis results for five bank positions related to discharge.

The model indicates:

- The 450 to 2,000 cfs bank position (blue) has dense riparian cover and offers little space for recruitment of new seedlings in areas that have not recently been disturbed by channel rehabilitation or flood disturbance. This zone is frequently inundated and can support dense riparian and wetland vegetation. Even still, Winter Flow Project increases the riparian recruitment in all water year types.
- The 2,000 to 4,500 cfs bank position (light green) offers the greatest potential for successful recruitment due to open and sparsely vegetated areas and relatively low bank elevation and therefore more frequent inundation, and successful riparian seedling recruitment has been previously observed under baseline conditions at this bank position. The Winter Flow Project would result in a notable increase in recruitment at this bank position in Extremely Wet and Normal water years.
- The 4,500 to 6,000 cfs bank position (aqua blue) also has open unpopulated areas, but experiences extremely low recruitment success due to high bank position and dry conditions unless irrigated. This elevation generally supports riparian vegetation recruitment at Normal, Wet, and Extremely Wet years under baseline conditions. Under the Winter Flow Project, less recruitment would occur at this bank position.
- Bank positions higher than 6,000 cfs (shown in dark blue and dark green) have extremely low modeled recruitment of black cottonwood seedlings under both scenarios as well as low previously observed successful recruitment under baseline conditions. This is because these areas are rarely inundated due to being high above the ordinary river flow's elevation, and only experience modeled recruitment during Wet and Extremely Wet years.

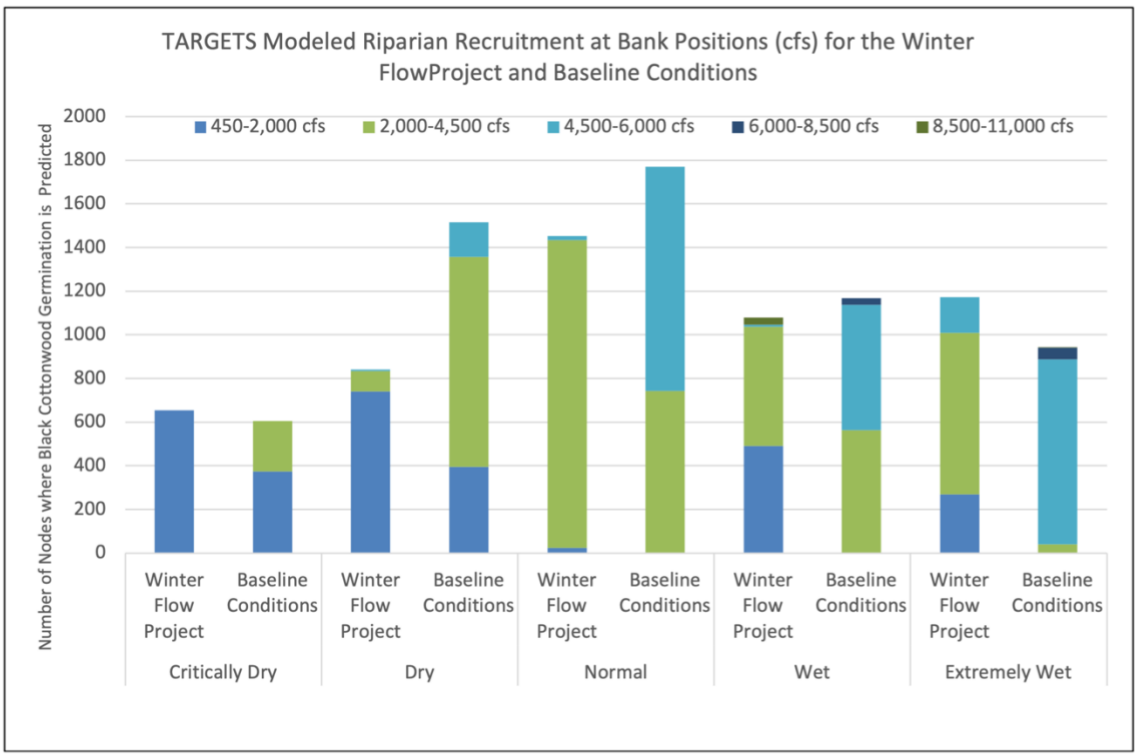
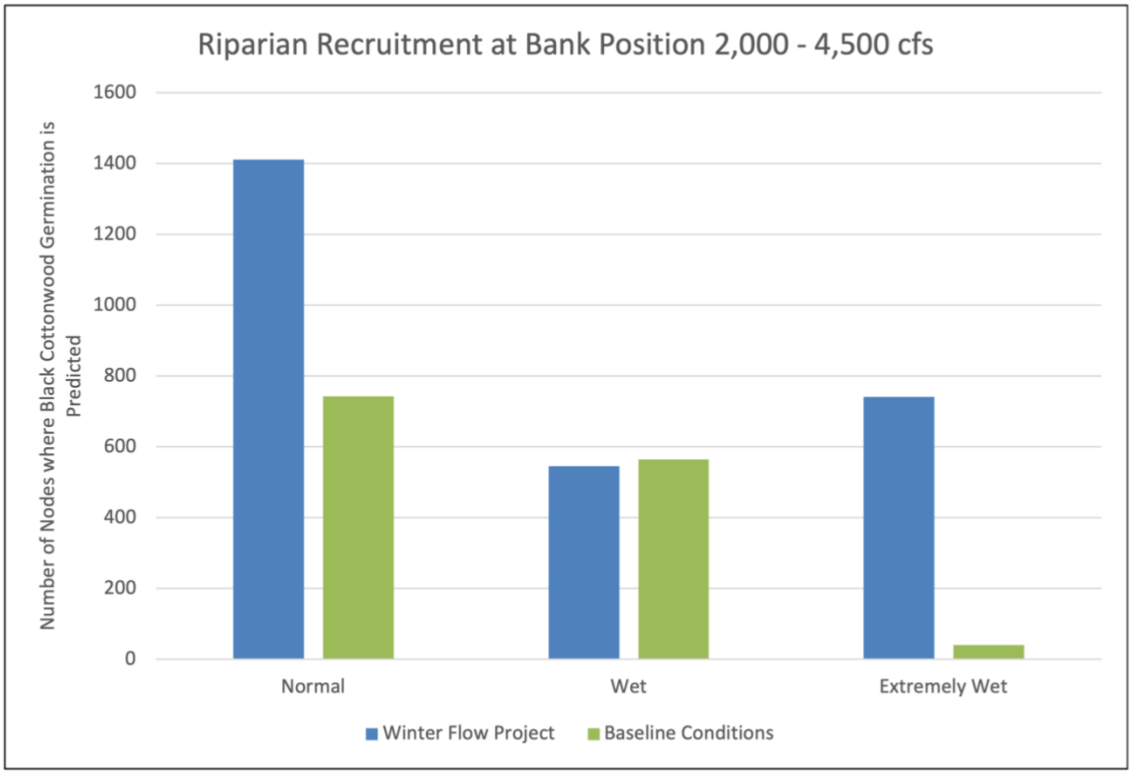


Figure 5-2. TARGETS model results from 2004-2019 for average nodes where Black Cottonwood recruitment occurs by water year type for the baseline conditions and the Winter Flow Project at 34 cross sections located within nine river segments from Lewiston Dam to North Fork Trinity River for five bins of bank position related to discharge.



Note: Only the bin related to discharge of 2,000 – 4,500 cfs is displayed, which has the most desirable combination of uninhabited space and high previously observed success related to riparian recruitment.

Figure 5-3. TARGETS model results from 2004-2019 for average nodes of Black Cottonwood recruitment by water year type for both scenarios at 34 cross sections located within nine river segments from Lewiston Dam to North Fork Trinity River for five bins of bank position related to discharge.

Winter Flow Project generally increases the recruitment during targeted years of Normal and wetter water year types in the target bank position (2000-4500 cfs; see Figure 5-3). Additionally, offering increased recruitment opportunities in all water year types for desired species within the lowest bank position (450-2000 cfs) may allow target species to better compete for establishment in freshly disturbed areas like channel rehabilitation sites prior to being outcompeted by less desired species which recruit later in the year (e.g., narrow-leaf willow). While the model for baseline conditions generally increases recruitment opportunities at the highest bank positions (>4500 cfs), where there is abundant space available for recruitment, infrequent recruitment success has been previously observed. Additionally, the model for baseline conditions essentially offers recruitment opportunities only at the lowest bank position in Dry and Critically Dry water years, which may prevent target species from effectively competing in freshly disturbed areas with low bank position and high recruitment potential.

While recruitment of black cottonwoods exists under both scenarios, the Winter Flow Project would increase the opportunity for riparian recruitment in Normal, Wet, and Extremely Wet water years by increasing the frequency of inundation at the bank positions that are under water at 4,500 cfs flows. The 2,000 to 4,500 cfs bank position offers the greatest potential for successful recruitment due to open and sparsely vegetated areas and relatively low bank elevation, as demonstrated by more frequent inundation and successful riparian seedling recruitment observed at this bank position under baseline conditions. The Winter Flow Project would result in a notable increase in recruitment at this bank position in Extremely Wet and Normal water years (Figure 5-3).

While the analysis presented in this report is informative, the Winter Flow Project is not limited to the hydrographs analyzed; they are merely hypothetical examples. There will be significant flexibility in the

management of water volumes that remain after the winter and early spring flow actions are taken. Results indicate that suitable volumes of water will remain to achieve riparian recruitment objectives during target years at the bank position with the most opportunity for recruitment success. Additionally, while limited in geographic scope, opportunities at low bank position in recently disturbed areas may occur more frequently due to reduced water volumes. Reducing water volumes later in the year will likely limit the recruitment potential above 4,500 cfs unless the remaining water volume is prioritized for this purpose.

5.4 Recreation

5.4.1 Baseline Conditions

Outdoor recreation is an important part of the social and economic character of Trinity County, and the Trinity River provides year-round commercial and private recreational opportunities, including boating, kayaking, canoeing, rafting, inner tubing, fishing, swimming, camping, gold panning, wildlife viewing, picnicking, hiking, and sightseeing. The study area for the recreation analysis is Trinity County. The topics of analysis include the economic characteristics of the recreation sector and access to recreation opportunities directly associated with the Trinity River. Section 3.8 of the Trinity River FEIS and Section 4.8 of the 2009 Master EIR give detailed description of the recreation environment along the Trinity River. (The Master EIR is available on the TRRP website at https://www.trrp.net/library/document/?id=476).

Campgrounds or other formal recreational sites, and access to public lands occur throughout the project area (Figure 5-4). Although public use is restricted at most private river access points, access to the Trinity River is available from public and private lands, with federal (i.e., U.S. Forest Service [Forest Service] and U.S. Bureau of Land Management [BLM]) and state agencies (i.e., CDFW) offering public river access points. Visitor use in the project area is heavy in places, with individuals and rafting and fishing companies using the river corridor.

The Trinity River was designated by the Secretary of the Interior as a federal Wild and Scenic River in 1981 under the 1968 Wild and Scenic Rivers Act (see https://www.rivers.gov/wsr-act.php). In addition to the mainstem Trinity River from the confluence with the Klamath River to 100 yards below Lewiston Dam, three Trinity River tributaries were also designated: North Fork Trinity River, South Fork Trinity River, and New River. The mainstem Trinity River from 100 yards below Lewiston Dam downstream to Cedar Flat is classified as a "Recreational" wild and scenic river. In 1998, BLM delineated the wild and scenic river corridor to include areas within 0.25 miles on either side of the river.

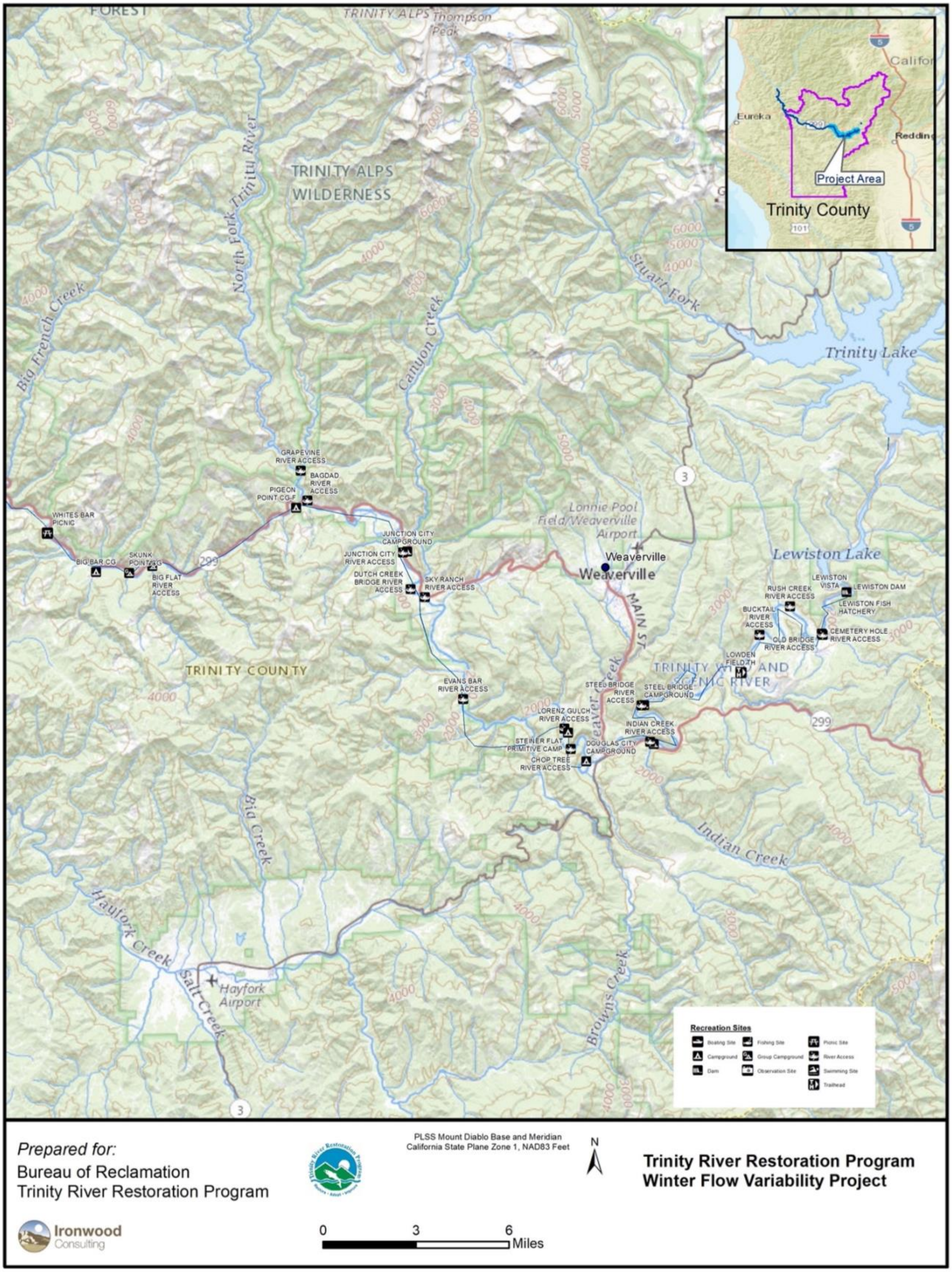


Figure 5-4. Recreation sites along the Trinity River, including boat ramps, campgrounds, and access points.

5.4.1.1 Trinity County Recreation Economy

The economic impacts of river recreation on the Trinity River recreation economy, also referred to as "travel and tourism" sector[19], employs 329 individuals and comprises about 22% of the total employment in Trinity County Economic Profile System 2020. In Trinity County, the proportion of tourism-related jobs is slightly higher than in the rest of the country (16%) and in California (17%).

Thirty individuals residing in Trinity County hold jobs related to recreation, including but not limited to fishing and rafting guides, which comprises about 2% of the total employment in the County. While this number represents individuals who are Trinity County residents, the recreation industry also employs seasonal staff who may have permanent residence outside of the area and are not accounted for in the official U.S. Census Bureau counts.

The proportion of individuals directly employed in recreation is comparable to that of the U.S. and California. Restaurant and lodging-related jobs account for 240 jobs, which is about 16% of Trinity County's employment. Retail-related businesses employ 59 people, which comprises 4% of the total employment. Both retail trade and restaurants and lodging employ a slightly higher proportion of individuals when compared to the United States and California.

Section 3.8 of the Trinity River FEIS analyzed the impacts of the then proposed ROD releases on the recreation, fishing, and boating economy, and found that implementation of the restoration releases under the ROD would result in benefits to the region's economic growth (USFWSa et al. 2000a). Data indicates that employment in recreation-related industry has increased slightly since the implementation of the ROD in 2004, while total jobs across all sectors has decreased in the same period (Economic Profile System 2020).

5.4.1.2 Recreational and Guided Fishing

Fishing for Chinook Salmon, steelhead, and resident trout is a major recreational activity on the Trinity River throughout the year. The protected status of both Coho Salmon and spring Chinook Salmon and CDFW's prohibition on take of wild (unmarked) steelhead, result from low run sizes that affect the fishing harvest quota, season length, and fish eligible for harvest. Fishing in the fly-water only section, downstream of the dam, is open April 1 through September 15 each year. The preferred flow ranges for fishing identified in the Trinity River FEIS (see Table 3-32 in the Trinity River FEIS) are 300 to 800 cfs for shore fishing and wading (wade fishing), and 200 to 1,500 cfs for drift-boat and drift-raft fishing (boat fishing; USFWS et al. 2000a). Fishing in the Trinity River occurs year-round, but the period between September and February is considered the height of the recreational and guided fishing season in the upper Trinity River reaches.

The BLM issues up to 100 permits for commercial fishing guides along the reach of Trinity River from Lewiston Dam downstream to Burnt Ranch (at Cedar Flat). In 2021, 22 of these fishing guide outfits were based in Trinity County, and most were based in neighboring Shasta County or other California counties. By agreement, the BLM manages commercial fishing guide permits and the Forest Service manages commercial boating and rafting

[19] Travel and Tourism includes businesses that provide goods and services to visitors and the local population. These industries are Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services. In 2018, the Department of Commerce first developed statistics illustrating the economic impact of outdoor recreation in the United States. See the Bureau of Economic Analysis's Outdoor Recreation Satellite Account at https://www.bea.gov/data/special-topics/outdoor-recreation.

permits on this Section of the Trinity River. Between 2015 and 2020, an average of 2,431 individuals hired fishing guides annually[20].

5.4.1.3 Recreational and Guided Boating

The Trinity River FEIS defines the river's primary recreation season as Memorial Day to Labor Day, or approximately the last week of May to the end of the first week in September. River guiding and recreational boating take place year-round and are not confined to the primary season. Rafting, kayaking, canoeing, and other water recreation activities are most popular during the primary season, which follows the current late April or early May restoration flow releases. The primary recreation season overlaps with the summer baseflow period when Trinity River flows are declining from spring peaks to the 450 cfs summer baseflow.

The Trinity River FEIS (Table 3-32 of the FEIS) identified flows ranging between 200 cfs and 8,000 cfs to be the preferred range for boaters, and the current flow regime under the ROD falls primarily within this range with peak flows that may exceed 8,000 cfs in late April through early June[21]. Comments from recreational boaters during the project public outreach identified preferred boating flows of generally between 1,000 and 2,000 cfs for the Pigeon Point run. The boatable flow range outlined in several guidebooks for this reach of the Trinity River is minimum at 500 cfs, optimal at 1,500 cfs and high at 4,000 cfs (Holbeck 1998, Menten 2016). River guiding usually takes place between summer baseflow (450 cfs) and 1,500 cfs.

The Forest Service issues 13 rafting permits for the river, from Lewiston Dam to Burnt Ranch. The reach most popular among rafting outfitters is the Pigeon Point reach, which is immediately downstream of the restoration reach and runs from the Pigeon Point campground to the Big Flat take out (Figure 5-4).

5.4.2 Analysis of Winter Flow Project on Recreation

5.4.2.1 Trinity County Recreation Economy

The Winter Flow Project is not likely to have a discernable effect on the recreational economy or employment in Trinity County. There may be a beneficial effect to the tourist economy as the river's fisheries improve and offer a more robust fishery for recreationists. Employment in the tourism and recreation sector, including the 2% of workers directly employed in the recreational economy, is unlikely to change.

5.4.2.2 Recreational and Guided Fishing

The Trinity River FEIS evaluated recreation-related impacts from flow management on the Trinity River. Both the baseline conditions and the Winter Flow Project will have benefits and adverse impacts on recreation opportunities on the Trinity River, depending on the activity, time of year, and water-year class. Specific analysis was performed for wade fishing and boat fishing, as the timing and duration of flows outside the preferred range for this activity will be affected. The flows identified as preferred for these activities in the Trinity River FEIS are 300-800 cfs for wade fishing and 200-1,500 cfs for boat fishing and can serve to describe impacts on

[20] Personal communication via email on September 30, 2021, between Jessica Tyra, Recreation Specialist with the BLM, Shasta Field Office, and Emily Thorn, Project Manager with Ironwood Consulting.

[21] The preferred ranges for boating include flatwater canoeing (200 to 1,500 cfs) and white-water kayaking, canoeing, and rafting (450 to 8,000 cfs).

swimming/inner-tubing and canoeing, respectively, as the flow requirements are similar, and impacts are the same.

The hypothetical hydrographs generated for baseline conditions and the Winter Flow Project for WY 2004 - 2019 were filtered by the preferred flow range for each activity to estimate fishable days. The Winter Flow Project flow was then compared to baseline conditions, such that if a day was fishable or not fishable in both baseline conditions and the Winter Flow Project there was no impact. If a day was fishable under baseline conditions, but not fishable under the Winter Flow Project, it was considered a lost day of recreation opportunity. Conversely, a day that was not fishable under the baseline conditions but was fishable under the Winter Flow Project was considered a gained day of recreation opportunity. Figure 3-3 and Section 3.3 show the thresholds for river recreation, including wade and boat fishing, with the hydrographs for the Winter Flow Project compared to the baseline conditions and the full natural flow (un-dammed) conditions for each water year type.

The Winter Flow Project would result in a recreational fishing environment that more closely mimics the pre-dam Trinity River than under baseline conditions, with increased river levels during storm runoff events and elevated winter baseflows (see Figure 3-3 and Section 3.3). While the experience of fishing in the Trinity River would be more like a natural free-flowing river, the Winter Flow Project would result in reduction of wade (300 to 800 cfs), and boat (200 to 1,500 cfs) fishing days during the winter and spring months (January through April), when compared with baseline conditions. Increased flows during the synchronization period would be short in duration, would generally coincide with storm events, and would be preceded by a 72-hour notification as described in Section 3.3 so that fishing during the synchronization periods could be avoided. This would result in inconvenience to fishers and long-term client scheduling by guides and might result in intermittent loss of wade and boat fishing days during the winter and spring months in some years.

The loss of fishing days would be greater in wetter years and would result in the most days lost during March and April (during the elevated base flow period), with generally few to no days lost in January and February. During the driest years, there would likely be no changes to fishing days in winter and spring and an increase to fishing days in May, June, and July. There would be no changes to the number of wade or boat fishing days between August and December in all water year types.

During the period between 2004 and 2019, lost wade and boat fishing days in January would have occurred in five of the 17 years analyzed. Lost wade and boat fishing days during February would have occurred in four of the 17 years analyzed. Table 5-4 outlines the average, minimum, and maximum days lost and gained by month for wade fishing and boat fishing in the Trinity River due to the Winter Flow Project.

The Winter Flow Project could result in an average annual loss of seven wade fishing days, with lost days between January and April gained days between May and July, and no changes between August and December. The return to the summer baseflow earlier in the season will increase the number of wade fishing days during the late spring and summer months, particularly for the fly fishing only reach.

The Winter Flow Project could result in an annual average increase of eight boat fishing days, with lost days occurring between January and May, gained days between June and July, and no changes between August and December. The gained and lost days for wade fishing are the same as for swimming/inner-tubing and the gained and lost days for boat fishing are the same as for canoeing.

Table 5-4. Average, minimum, and maximum impact to wade and boat fishing days gained or (lost) below Lewiston Dam for WY 2004-2019 from the Winter Flow Project compared to baseline conditions.

	Change in Days of Wade Fishing (<800 cfs)			Change in Days of Boat Fishing (200-1500 cfs)		
Month	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**
October		0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	-4	0	-13	-3	0	-8
February	-4	0	-15	-1	0	-8
March	-14	-3	-31	-5	0	-17
April	-24	-14	-30	-16	0	-30
May	+8	+26	-2	+10	+30	0
June	+19	+30	+9	+18	+30	0
July	+12	+29	0	+5	+11	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual	**-7**	**+13**	**-34**	**+8**	**+29**	**-7**

The near- and long-term benefits to fisheries from this more natural flow regime would result in increased quality of recreational fishing opportunities when compared to the baseline conditions. Recreational fishing opportunities would potentially increase over time under the Winter Flow Project because the project is designed to create productive seasonal habitat for salmon through flooding, food availability through scour and drift, and optimal temperature ranges for different life stages (see Section 4.). If runs were restored, fishing opportunities could increase through expanded seasons, increased quotas, and removal of take prohibitions. While the direct and near-term impacts of Winter Flow Project would be on juvenile fish, the long-term impacts would improve fishing opportunities by increasing the size and number of smolts that leave the Trinity River, therefore increasing the health of the fishery and the rates of return of adult salmon.

5.4.2.3 Recreational and Guided Boating

Based on comments and analysis submitted during the project public outreach by the American Whitewater Association, there would be no substantial impact to the number of boatable days among the minimum (500 cfs), optimum (1,500 cfs), and high (4,000 cfs) river flow ranges that are preferred by the recreational boating community during the summer months. Additional analysis was not performed for whitewater activities (i.e., kayaking and rafting).

Under the Winter Flow Project, the overall volume of restoration releases would remain the same as baseline conditions, as mandated under the ROD. However, a portion of the restoration releases that have occurred during June and July since 2004, when the ROD was implemented, would be moved earlier in the year to be synchronized with winter runoff events in Trinity River tributaries. This could impact the experience of recreational boaters and boat guides who have grown accustomed to consistent low winter releases from Lewiston dam and higher releases in May and June.

Summer 450 cfs baseflows would be reached earlier in the summer under the Winter Flow Project, around late June, or early July, versus late July under the baseline conditions. The earlier summer baseflow period may impact recreational boating by shortening the duration of the receding limb of the restoration flow releases, thereby impacting the experiences of the proportion of recreational boaters and raft outfitter clients who prefer higher levels during those periods, but not those who enjoy lower flows (see Figure 3-3). Under the Winter Flow Project, the optimum boating range may occur earlier in the summer when compared to the baseline conditions. Lewiston Dam releases would not be reduced below the summer ROD baseflow of 450 cfs.

Spring flows during the Elevated Baseflow Period would be increased so that a beneficial effect to recreational boating may occur. Other sections of the river and types of boating (e.g., stand-up paddle boards) may also be desirable during these elevated flows. The elevated baseflow would result in consistent flows in March and April that would fall within the preferred flow range for boaters. While the elevated baseflow falls outside of the primary rafting season, it may provide an expanded boating season for local recreationists and spring season tourists.

5.5 Energy and Utilities

5.5.1 Background

Electricity produced at the Trinity Power Plant and the Lewiston Power Plant is utilized in surrounding communities. Between 2010 and 2019 the market value of TRD-generated power was approximately $121.3 million. Annual market value during that period ranged from $8.8 million in 2016 to $16.9 in 2013 (Table 5-5). The market value of power generated at the Trinity Power Plant is dependent on both the amount of power that is generated and the market value of power at the time of generation. A detailed description of the power resources affected environment can be found in Section 3.10 of the Trinity River FEIS.

5.5.2 Analysis of Winter Flow Project on Power Markets

To understand the potential effects to the market value of generated power at the Trinity Power Plant, an analysis was completed with the caveat that actual future impacts will be dependent on the magnitude of generation and market value of power at the time of generation. The analysis is based on the RBM10 dataset for the baseline conditions and the proposed release rates under the Winter Flow Project for years 2010 and 2019, which is the period for which power market rates are known. The analysis is therefore not predictive of future market value and potential impacts, but rather illustrates how past market value of generated power would have been impacted by the Winter Flow Project when compared to the baseline conditions. This provides insight into how future market value of energy production may be impacted by the Winter Flow Project.

The analysis completed through the following steps, for both the baseline conditions and the Winter Flow Project:

- Total Trinity Release Rate was determined using the Lewiston baseline condition and Winter Flow Project release rates, maximum release rates and historic release rates[22].

[22] For the baseline conditions scenario, the total Trinity release rate was calculated as the maximum of the baseline Lewiston release rate and historically recorded Trinity release rate. For the Winter Flow Project scenario, the total Trinity release rate was calculated as the maximum of the Winter Flow Project Lewiston release rate and historically recorded Trinity

- The Trinity Power Generation (Trinity Gen) was determined by the potential range of energy produced by the baseline conditions and the Winter Flow Variability total Trinity release rates and 3,000 cfs, which is the maximum release rate at which energy can be produced at Lewiston Dam[23].
- The magnitude of generation in megawatt hour (MWh) was calculated using the Trinity Gen.
- The value market of power was determined by multiplying the magnitude of generation by the N15 Market rate of power generation from the analysis period[24].

Yearly results are shown in Table 5-5.

Table 5-5. Trinity Power Plant generation market value ($ Millions) and percent difference under baseline conditions and the Winter Flow Project (modeled).

Year	Water Year Type	Trinity Power Plant Generation Market Value ($ million)			
		Baseline Conditions	Winter Flow Project	Market Value Difference	Percent Difference
2010	Normal	10.64	10.94	0.30	2.8%
2011	Wet	12.46	12.98	0.52	4.0%
2012	Normal	11.52	11.33	-0.19	-1.7%
2013	Dry	16.86	17.37	0.51	3.0%
2014	Critically Dry	16.86	16.78	-0.08	-0.1%
2015	Dry	10.72	10.60	-0.12	-1.3%
2016	Wet	8.79	8.52	-0.27	-3.1%
2017	Extremely Wet	13.31	13.48	0.17	1.3%
2018	Critically Dry	10.11	10.15	0.04	0.4%
2019	Wet	10.05	11.72	1.67	15.3%
Total	**All Water Year Types**	**121.4**	**123.9**	**2.5**	**2.1%**

The analysis shows that there would have been no substantial change to the market value of energy when applied to the analysis period when compared to baseline conditions. The variation between the two scenarios is minimal except for calendar year 2019, when the Winter Flow Project would have resulted in a substantial increase (15.3%), and therefore a significant benefit, to the market value of Trinity Power Plant energy. Given the unpredictable dynamics of market rates of power, there is no reliable way to predict future impacts of the Winter

release rate, minus historic Lewiston release rate, plus the Winter Flow Project Lewiston release rate. This provides the same assurances as in the baseline conditions scenario.

[23] Trinity Power Generation (Trinity Gen) release rate was calculated using the baseline conditions and Winter Flow Project Trinity release rates. For both scenarios the Trinity Gen release rate was calculated as the minimum of the total Trinity release rate and 3,000 cfs, the upper Trinity Power Plant capacity imposed for this analysis.

[24] Using the calculated Trinity Gen release rates, the magnitude of generation in megawatt hour (MWh) under both scenarios was calculated. For both scenarios, this was calculated using a linear equation that estimates the MWh based on Trinity Gen release rates. The equation was developed by applying a linear regression to the historically recorded Trinity Gen and MWh for this same period. The Trinity Power Plant MWh Generation as a function of Trinity Power Plant Generation Flow Rate is:

$$MWh = MAX(0, 0.7463 * Trinity\ Gen - 33.1452)$$

Flow Project on the value of generated power. However, based upon comparisons of recent annual power production values, it is likely that the Winter Flow Project would result in no substantial impact to the market value of the energy produced by the Trinity Power Plant.

Power interests (North Coast Power Association and the Western Area Power Administration) commented on the public Draft Winter Flow Variability EA, noting how power pricing is variable and that the forward price predicts that future summer prices will be higher than winter energy prices. Consequently, Reclamation performed additional analysis using the forward pricing predictions and provided the results to the commentors. Reclamation agreed to perform an annual analysis to estimate the market value differences under the Winter Flow Project if implemented, compared to the baseline conditions. Although Reclamation's predictions anticipate minimal power production differences, revenues will be tracked.

6. Stakeholder Input and Review

6.1 Winter Flow Project Background

6.1.1 Winter Flow Project Design and Analysis Process

In September 2020, TRRP prepared and provided to the TMC a memorandum outlining the Flow Workgroup's conceptual plan for exploring the potential benefits of modifying the winter flow regime within the parameters of the ROD. In response to this memo, the TMC instructed the Program to perform the analysis necessary to implement the action. A team of collaborating scientists from TRRP partner entities began evaluating various approaches to flow regime modification in January 2021 and their evaluation resulted in the completion of a white paper entitled *Shifting a Portion of Trinity River Spring Releases from Lewiston Dam to the Winter Period: A Flow Management Action to Benefit Juvenile Salmonid Habitat Availability, Growth, and Outmigrant Timing* (Abel et al. 2021) that outlines the basis for the Winter Flow Project. The major concepts and elements of the White Paper have been included in this report in Section 3.

The TRRP's Science Advisory Board (SAB) provided edits on an earlier version of the project white paper in August 2021. The SAB reviewers noted that at the time of the ROD, the natural flow paradigm, on which the Winter Flow Project is based, was well established in the scientific literature and has been increasingly applied in river science since. They supported the more natural timing of water delivery and inquired about the reasons the ROD had not initially shifted a larger portion of available flow to match natural seasonal patterns, as proposed under the Winter Flow Project, and provided substantive comments that the TRRP incorporated into the project approach (see Section 2.). The Winter Flow Variability proposal is a first step at providing winter fishery releases and the next step in more natural water flow management.

Between January and November 2021, TRRP collaborating scientists met weekly and completed analysis, modeling, and refinement of the Winter Flow Project's potential outcomes with respect to geomorphology and soils, hydrology and flooding, vegetation, fishery resources, recreation, and energy and utilities, which are described in Sections 3, 4, and 5 of this report.

6.1.2 Environmental Compliance and Review Process

The concept for an alternative flow regime was first discussed by the TRRP Flow Workgroup in 2017[25] which prepared a Draft Supplementary Information Report (Draft SIR) to explore the potential of modifying the winter flow regime with respect to the parameters outlined in the ROD. Following the initial Draft SIR, Reclamation decided to proceed with an environmental assessment (EA)[26] to augment existing analyses in 2021. The Draft EA was released in September 2021 for public comment. Subsequently, Reclamation determined that a Final EA and Finding of No Significant Impact (FONSI) was not required to implement the project due to the authorization under the 2000 ROD to use AEAM principals to adjust the timing of restoration releases within the ROD-

[25] Information on the project concept discussed in 2017 at the Flow Workgroup can be found at https://www.trrp.net/flow-temperature-workgroup/)

[26] An Environmental Assessment is prepared to comply with the National Environmental Policy Act, when a federal agency proposed to partake or approve of an action that involves federally managed resources.

determined volumes. Reclamation directed that the Winter Flow Project could be implemented upon approval by the TMC.

6.1.2.1 Public Comment Periods

TRRP held two public comment periods for the Winter Flow Project during the preparation of the EA. The TRRP received scoping comments from 72 individuals or organizations, totaling 79 unique comments categorized into eight topics.

Public scoping for the Winter Flow Project was from May 18, 2021, to June 18, 2021. The Winter Flow Project Draft EA was available for public review and comment from September 17, 2021, to October 21, 2021. A virtual public meeting took place on Tuesday, October 5, 2021, at 6 PM Pacific Standard Time. Nineteen individual comments letters from members of the public and interested parties were received during the Draft EA public comment period

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